"A STUDY ON ENVIRONMENTAL SUSTAINABLE PRACTICES IN INDIAN MAJOR PORTS"

A dissertation submitted in partial fulfilment for award of the degree of

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DECLARATION

I, **AWANISH KUMAR CHAUBEY** bearing Register Number: **2203305009**, student of MBA – International Transportation & Logistics Management, at School of Maritime Management, Indian Maritime University, Chennai Campus, hereby declare that the dissertation titled **"A STUDY ON ENVIRONMENTAL SUSTAIBLE PRACTICES IN INDIAN MAJOR PORTS"** is my original work. This report is being submitted in partial fulfilment of the requirement for the award of the degree of Master of Business Administration (MBA) In International Transportation and Logistics Management (ITLM). The project report is output of my learnings and observations of my research under the guidance of Dr Emil Mathew, Assistant professor School of Maritime Management, Indian Maritime University, Chennai Campus.

I declare that the information submitted is true and original to the best of my knowledge.

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CERTIFICATE

This is to certify that this dissertation entitled **"A STUDY ON THE ENVIRONMENTAL SUSTAINABLE PRACTICES IN INDIAN MAJOR PORTS"**- submitted to the School of Maritime Management, Indian Maritime University, Chennai Campus in partial fulfilment of the requirement for awarding the degree, MBA in International Transport and Logistics Management is a work of **AWANISH KUMAR CHAUBEY (Reg No. 2203305009)**.

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EXECUTIVE SUMMARY

India, a burgeoning maritime power, is grappling with the crucial task of balancing its economic growth with environmental responsibility. This challenge extends to its major ports, which serve as vital lifelines for trade but can also be significant sources of pollution. Recognizing this, the Indian government and various port authorities have embarked on a journey towards environmental sustainability, christened "Green Ports."

The greening of major ports in India extends beyond operational practices. Sustainable port infrastructure is being developed, with a focus on minimizing ecological disruption during construction and promoting biodiversity. This may involve creating green belts, restoring natural habitats, and employing eco-friendly building materials.

The success of the Green Ports initiative hinges on active collaboration between various stakeholders. The government's role is crucial in providing policy frameworks, financial incentives, and promoting research and development in green technologies. Port authorities need to invest in green infrastructure and operations, while shipping companies must adopt environmentally conscious practices. Knowledge sharing and capacity building within the sector are also essential for widespread adoption of sustainable solutions.

In conclusion, the greening of Indian major ports signifies a crucial step towards a more sustainable maritime future. By overcoming the challenges and capitalizing on the opportunities, India can position itself as a leader in environmentally responsible port operations, ensuring economic prosperity in harmony with environmental well-being.

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CHAPTER - 01

1.1 Introduction to Environmental Sustainable Practices at ports:

India's economy heavily depends on the maritime industry due to its extensive 7,500 km of coastline and its twelve major ports. On the other hand, detrimental effects on the environment and society have frequently been linked to port growth. India's ports are seeing an increasing focus on sustainable development in recent years. An all-encompassing strategy that considers the social, environmental, and economic facets of port development is required for the sustainable development of ports in India. Its goal is to guarantee that ports are developed in a way that is socially inclusive, environmentally conscious, and commercially sustainable.

Some of the key elements of sustainable development of ports in India include:

1. **Environmental sustainability**: This involves minimizing the environmental impact of port development by adopting sustainable practices such as energy-efficient operations, use of renewable energy sources, reduction of greenhouse gas emissions, and the protection of biodiversity and marine life.
2. **Social sustainability**: This involves ensuring that the benefits of port development are shared equitably among all stakeholders, including local communities, port workers, and other stakeholders. It also involves ensuring that the health and safety of port workers and local communities are protected.
3. **Economic sustainability**: This involves developing ports in a manner that is financially viable and provides long-term economic benefits. This includes investments in infrastructure, technology, and human resources.
4. **Collaboration and stakeholder engagement**: Sustainable development of ports in India requires collaboration among all stakeholders, including port authorities, government agencies, local communities, and private sector partners. Stakeholder engagement is essential to ensure that the concerns and interests of all stakeholders are addressed.

Sustainable development of ports in India refers to the process of creating, operating, and managing ports in a way that promotes economic growth while minimizing environmental impacts and promoting social well-being. The ports of India play a critical role in the country's economy, serving as a gateway for international trade and commerce. However, these ports also have a

significant impact on the environment, and the challenge is to balance economic growth with environmental sustainability.

The Indian government has taken several measures to promote sustainable development of ports. One of the significant steps is the adoption of the Green Port Policy, which aims to make ports environmentally sustainable by reducing the carbon footprint and promoting the use of renewable energy. The policy includes measures such as the use of energy-efficient equipment, adoption of eco-friendly transportation, waste management, and the use of renewable energy sources like solar and wind power.

In addition to the Green Port Policy, the Indian government has also launched several initiatives to improve the infrastructure of ports, including the development of new ports and expansion of existing ones. The government has also introduced policies to promote the use of alternative modes of transportation like coastal shipping and inland waterways to reduce road congestion and pollution.

Furthermore, the government is actively promoting public-private partnerships (PPPs) to attract investment in port infrastructure development. This approach ensures that the private sector brings in the capital, technology, and expertise required to develop ports while the government provides the necessary policy framework and infrastructure support.

In short, sustainable development of ports in India is critical for the country's economic growth and environmental sustainability. The government has taken several measures to promote sustainable development, including the adoption of the Green Port Policy, infrastructure development, and the promotion of PPPs. These initiatives are essential to ensure that India's ports remain competitive while minimizing their environmental impact and promoting social well-being.

Fig 1- Indian Major ports.

1.1.1 Environmental Sustainability in Ports:

The lifeblood of international commerce, ports serve as vital hubs for the movement of goods across the globe. However, this critical function comes at a cost, with port operations often leaving a significant footprint on the environment. Environmental sustainability in ports emerges as a response to this challenge, striving to minimize this impact and ensure that the development and operation of these crucial centers coexist harmoniously with the surrounding ecosystems.

Energy Efficiency: The high volume of activity within a port necessitates a constant influx of energy to power cargo handling, terminal operations, and extensive lighting systems. However, sustainable practices are taking aim at this considerable energy consumption. Upgrading equipment to more efficient models, strategically implementing LED lighting across the entire port infrastructure, and optimizing processes to eliminate unnecessary energy use are all crucial aspects of this environmental commitment.

- **Renewable Energy Sources:** Transitioning away from fossil fuels is crucial for reducing a port's carbon footprint. Ports can invest in solar panels, wind turbines, or even harness the power of tides and waves to generate clean energy. This not only benefits the environment, but also reduces the port's reliance on fluctuating fossil fuel prices.
- **Greenhouse Gas Reduction:** Ship emissions and port operations are major contributors to greenhouse gases (GHGs) like CO2. Sustainable practices aim to tackle this challenge. This can involve encouraging the use of cleaner-burning fuels for ships, investing in shore-side power to reduce ship engine emissions while docked, and implementing stricter regulations on cargo handling practices to minimize dust and air pollution.
- **Protecting Biodiversity and Marine Life:** Ports are often located in ecologically sensitive areas. Sustainable practices strive to minimize disruption to these ecosystems. This can involve careful planning of port expansions to avoid harming critical habitats, implementing measures to reduce noise pollution that affects marine life, and even creating artificial habitats within the port to promote biodiversity.

1.1.2 The Road to Sustainability

Achieving environmental sustainability in ports requires a collaborative effort. Port authorities, shipping companies, government agencies, and local communities all have a role to play. By implementing these practices, ports can ensure continued economic growth while safeguarding the environment for future generations. Here are some additional points to consider:

- **Waste Management:** Implementing effective waste management systems is crucial. This involves segregating waste streams, promoting recycling and composting initiatives, and ensuring proper disposal of hazardous materials.

- **Innovation:** Continuously exploring and adopting new green technologies is essential. This can range from using electric vehicles for cargo handling to utilizing drones for port inspections, all aimed at minimizing environmental impact.
- **Community Engagement:** Ports must work closely with surrounding communities to understand and address their environmental concerns. This can involve open communication channels, collaborative planning processes, and even joint restoration projects for impacted ecosystems.

By adopting a comprehensive approach to environmental sustainability, ports can become not just economic engines, but also responsible stewards of the environment. This ensures a thriving maritime trade sector that coexists harmoniously with a healthy planet.

1.2 Research Question

Ports in India: Can sustainability and Port productivity go hand in hand?

1.3 Objectives of the study

1. To study the ports operations in terms of Environmental sustainability.
2. To study the scheme & plans of government for sustainable port practices.
3. Challenges towards sustainable port practices in India.
4. To study how ports are using technology to increase profitability and sustainability.
5. Governmental policies and their implementation for green sustainable port and shipping.
6. Steps and practices used to move towards greener and more sustainable port and shipping initiatives.

1.4 Scope of the study

1. The study is all about the people expectation towards the sustainability on port industry.
2. The study conducted is to find out the working of the major ports and the shipping to have a thorough knowledge of the practices and working of the maritime sector concerning its

productivity, efficiency, and greener port and shipping policies for the betterment of individual (stakeholders and the non-stakeholders), property and environment.

3. The study also focuses on how the challenges coming towards sustainability is getting resolved by government's plans & schemes.

1.5 Limitations of the study

Though the study has been conducted through planned research, there are certain limitations, which are inherent in nature and are out of the researcher's control. Such important limitations of the study are stated below:

- The study is based on both primary data & secondary data. As to complete a full fledge study both the data have been considered.

1.6 Research methodology

The research methodology for the study of Environmental Sustainable Practices in Indian major ports will involve the following steps:

Literature review: A comprehensive review of relevant literature, including academic articles, reports, and policy documents, will be conducted to identify the regulatory and policy frameworks governing green ports in India, the technological innovations and best practices adopted by Indian ports, and the economic, environmental, and social impacts of green port initiatives.

Data analysis: Data on the economic, environmental, and social impacts of green port initiatives will be collected and analyzed using appropriate statistical methods. The analysis will aim to identify the key drivers of sustainable development in Indian major ports and evaluate the effectiveness of green port initiatives in achieving sustainability goals.

Expert consultations: Expert consultations with stakeholders, including port officials, industry representatives, and sustainability experts, will be conducted to gather insights and perspectives on the current state of green port initiatives in India and the potential for future developments.

Recommendations: Based on the findings of the study, recommendations will be developed for enhancing the sustainability performance of Indian ports and promoting the adoption of best practices and innovations. The recommendations will be aimed at policymakers, port authorities, and other stakeholders involved in green port initiatives.

CHAPTER – 02

2.1 Review of Literature

Title: Environmental Policy Frameworks for Ports: In Search of a Gold Standard.

Author: Meinhard Doelle, Tafsir Johansson, Aspasia Pastra

Date of Publication: 2023

Conclusions & Findings: Recognizing the significant environmental impact of ports, researchers are actively seeking to define a "gold standard" for environmental policy frameworks within this sector. This quest for optimal policy involves a multifaceted approach. Firstly, in-depth analysis is conducted through academic literature review and examination of existing international and regional port policies. Secondly, researchers directly engage with experts, with interviews conducted to glean insights from industry professionals. Building upon a prior framework by Christodoulou et al., which identified the port itself, its role in supporting transportation, and the surrounding geographic area as key spheres of influence, this research broadens the scope. The current study emphasizes not just greenhouse gas reduction, but a holistic approach to environmental sustainability across all port operations. Ultimately, achieving a "gold standard" requires a proactive and collaborative effort. The port authority itself must champion sustainability initiatives, while fostering cooperation with shipping lines, inland transportation providers, and the surrounding communities. Through ongoing adaptation and collaboration, this framework can evolve to ensure ports remain responsible stewards of the environment.

Title: Investigation of Green Port Strategy in Sustainable Port Approach

Author: Dwijendra K. Gupta

Date of Publication: 2023

Conclusions & Findings: The concept of a "green port" signifies a commitment to environmentally responsible practices throughout port operations. These practices form a long-term strategic approach, ensuring the port's long-term environmental sustainability. This study specifically delves into the environmental dimension of sustainability, a concept of paramount importance in today's world. Through a comprehensive literature review on green port strategies,

the study identified and analyzed a range of key indicators.These indicators encompass air quality, climate change mitigation strategies, energy efficiency, noise pollution, positive relationships with the local community, water quality management, ship waste handling, responsible dredging and port development practices, and effective management of both garbage and port-generated waste.

Title: Sustainability Assessment of Master Commercial European Ports Through Environmental Prismas

Author: Oliver Cromwell

Date of Publication: 2023

Conclusions & Findings: In the wake of the global pandemic, the spotlight shines brightly on European ports. The world watches with keen interest to see how these vital hubs can not only resume smooth operations and restore economic and social value, but also achieve this in an environmentally sustainable manner. A multi-pronged approach is crucial, with healthy environmental practices, robust safety measures, and a shift towards renewable energy sources like wind and solar power taking center stage. Furthermore, effective waste management will be a key differentiator. Benchmarking environmental responsibility and performance will become a hallmark of evaluating Europe's master ports. Climate change necessitates a transformation of port operations, prompting the question: how can automation through robotics contribute to overall sustainability within the transportation sector? While digitization and innovative operational processes are paramount for success, it's important to acknowledge the unique regulations and management styles of each port. These must be carefully aligned with current government policies. One wonders then, does this alignment imply a leading role for powerful nations in shaping and maintaining the environmental management systems adopted by these master ports?

Title: Green Ports - Sustainable Port Development

Author: P McCallum

Date of Publication: 2022

Conclusions & Findings: The concept of a "green port" signifies a commitment to balancing economic growth with environmental responsibility. While the booming global trade necessitates port expansion to accommodate larger vessels, increased capacity often comes at a cost to surrounding communities and ecosystems. Larger berths, wider navigable areas, and expanded road and rail networks can strain the environment and test public acceptance of port development projects. In response to growing public concern, governments are enacting stricter environmental regulations. To navigate this complex landscape and ensure long-term viability, ports must embrace sustainable development and operational practices. This "social license to operate" requires a commitment to environmental stewardship alongside economic progress. Only through sustainable port development plans and ongoing operations can ports thrive in harmony with the natural world and surrounding communities.

Title: Assessing Dry Ports' Environmental Sustainability

Author: Erica Varese, Christian Bux, Vera Amicarelli, Mariarosaria Lombardi

Date of Publication: 2022

Conclusions & Findings: The growing emphasis on sustainable development and environmental responsibility within the maritime industry has spurred the exploration of greener practices, including the development of dry ports. However, a significant knowledge gap exists regarding the precise environmental impact of dry ports. While a limited number of studies have touched upon this topic, they tend to be general in nature, leaving a critical lack of in-depth research on the ecological implications of dry ports.

To bridge this gap and stimulate further academic inquiry, this review aims to establish a novel conceptual framework specifically focused on the environmental aspects of dry ports. The authors employed a systematic literature review, meticulously combing through databases like Scopus and Web of Science. From an initial pool of 107 relevant articles, 43 were ultimately selected based on the authors' defined criteria. The analysis revealed three key findings: (1) a concerning lack of coordination between existing studies and a comprehensive discussion on the environmental impact of dry ports; (2) the absence of standardized tools for evaluating these impacts; and (3) a critical gap in stakeholder involvement within the research process. Furthermore, the review

highlights the need to analyze dry ports within the broader context of the United Nations Agenda 2030's Sustainable Development Goals.

Title: Assessment of environmental sustainability issues for South-Asian maritime ports

Author: Kapil Vinod Gupta, Gyan Prakash

Date of Publication: 2022

Conclusions & Findings: Despite the surge in research on "maritime sustainability," a geographical bias persists. While European and North American ports have been extensively studied, a significant knowledge gap exists regarding South Asian ports. This research aims to address this gap by focusing on eleven major South Asian maritime hubs. Through a comprehensive literature review, the study identifies the most pressing environmental sustainability issues currently facing these ports. An Importance-Performance Analysis (IPA) technique is then employed to rank the identified issues based on their significance. Leveraging the Segmented String Relative Ranking algorithm, the research subsequently ranks the eleven ports themselves based on their performance in addressing these critical sustainability concerns. This multifaceted approach allows for a long-term analysis of environmental practices within South Asian ports. The analysis reveals that the Port of Malé (Maldives), Jawaharlal Nehru Port (Mumbai, India), and the Port of Colombo (Sri Lanka) emerge as the top performers in terms of environmental sustainability.

Title: Environmental Sustainability in Ports

Author: Eduardo Lalla-Ruiz, Eduardo Lalla-Ruiz, Leonard Heilig, Stefan Voß

Date of Publication: 2019

Conclusions & Findings: As environmental regulations tighten their grip on the maritime industry, stakeholders must embrace a holistic approach. Understanding the ecological benefits of "green" solutions is no longer enough. The industry craves a vision that demonstrates the positive synergies between environmental practices and operational/economic performance. In essence, the

industry seeks structures, processes, technologies, and methods that can fulfill both economic and environmental objectives simultaneously. This pursuit of "sustainable growth and development" demands a framework that incorporates environmental indicators into modelling and decision-making processes. This chapter introduces the concept of environmental sustainability in ports and proposes such a framework. It encompasses various tools and strategies currently being explored by researchers and industry leaders to address environmental concerns across different operational levels within a port. Focusing specifically on the realm of planning and optimization, the chapter provides an overview of port operations and uses the example of berthing activities to illustrate how concepts like "slow steaming" can be factored into decision-making for a more sustainable future.

Title: Green Ports and Sustainable Shipping in the European Context

Author: Ziaul Haque Munim, Rana Saha

Date of Publication: 2021

Conclusions & Findings: Ship emissions are a major concern for stakeholders due to their detrimental impact on climate change and surrounding communities. In response, European countries, alongside global efforts, are actively developing strategies, technologies, and regulations to curb the environmental footprint of the maritime industry. This chapter delves into "green port" and sustainable shipping practices being implemented within the European maritime transport network. Divided into three distinct regions – the North and Baltic Seas, the Mediterranean Sea, and the Black Sea – the chapter explores the green practices and relevant regulations specific to each area. Furthermore, it proposes a high-level conceptual framework to guide the implementation of these green port and shipping practices. The chapter concludes by outlining potential avenues for future research in this critical domain.

Title: Environmental governance in shipping and ports: Sustainability and scale challenges

Author: Jason Monios

Date of Publication: 2020

Conclusions & Findings: This chapter dissects the intricate web of environmental governance in the global shipping and ports sector. A complex interplay exists, with regulations and planning regimes established at various levels – from the all-encompassing International Maritime Organization (IMO) down to specific local ordinances. However, this very multi-layered approach presents challenges. Overlapping jurisdictions and a hesitancy to invest leave crucial issues inadequately addressed. These issues range from air and water pollution to noise and congestion in port areas, and even the critical issue of climate change adaptation. By bringing these "scale conflicts" and internal dynamics to light, the chapter exposes current institutional weaknesses that demand decisive action from policymakers. While maritime policy remains inherently polycentric with a strong global influence, the chapter argues that national policies addressing climate change adaptation are poised to play an increasingly prominent role in shaping the future of maritime transport and trade.

Title: Use of Marine Renewable Energy in Ports of Middle East: A Step Toward Sustainable Ports

Author: Khushboo Shah

Date of Publication: 2022

Conclusions & Findings: Renewable energies, harnessed from naturally replenishing sources like wind and sun, offer a compelling solution for reducing environmental impact and CO2 emissions. Their economic benefits and eco-friendly nature have propelled them to the forefront of global energy sources. Ports, as vital economic arteries facilitating international trade, must also embrace sustainability principles. The PIANC Report on Renewable and Energy Efficiency for Ports (2019) underscores this very need. Integration of renewable energy into port operations is key to achieving this goal. A variety of renewable sources exist, including wind, solar, wave, tidal, ocean thermal, and salinity gradient energy. Wave, tidal, and ocean thermal conversion (OTEC) technologies, along with salinity gradient power, fall under the umbrella of marine renewable energy. The proximity of ports to vast stretches of open water, coupled with their expansive areas, makes them ideally suited to harness these renewable resources. Feasibility studies, energy usage analysis,

research to overcome implementation hurdles, and the development of site-specific devices are all crucial steps towards making renewable energy a reality for port communities. By embracing these advancements, ports can propel themselves towards a greener future.

CHAPTER – 03

3.1 Introduction to Industry:

Ports are important gateways for international trade and play an important part in the global economy, however, port operations can hurt the environment. Some of the major environmental concerns associated with port activities are air and water pollutants, marine sediments, noise, trash generation, loss and deterioration of terrestrial habitats, and changes to marine ecosystems. Environmental management in port operations is a rapidly increasing trend, with many ports across the world implementing various methodologies and projects to improve environmental performance.

However, this progress is uneven. While many ports have embraced "green port" initiatives, promoting sustainable growth and development, others lag behind. This essay aims to analyze the optimal course of action for such lagging ports to achieve "green port" status on both practical and theoretical levels. The growing emphasis on environmental protection within corporate social responsibility has spurred shipping companies to recognize the value of greening their operations, understanding their role in a global community reliant on international trade.

The surge in international trade following globalization has propelled the transportation sector onto a superfast growth trajectory. Unfortunately, this growth has come at a cost, as the sector is now a major contributor to greenhouse gas emissions. With shipping emissions projected to increase by a staggering 250% by 2050, the need for mitigation measures becomes all the more pressing. Ports, numbering in the thousands, serve as crucial hubs where cargo transitions from sea to land-based transportation networks like railways and roadways. Sustainable practices implemented by ports have the potential to positively impact the entire global supply chain. Identifying the most pressing areas within the supply chain that require immediate attention is a dire need for the international community.

The pre-pandemic era offers a stark illustration of the global shipping industry's scale. In 2018, a staggering lakh of ships crisscrossed sea routes, transporting a colossal 11 billion tons of cargo. This volume represents roughly 80% of global trade by quantity and a significant 70% by value [UNCTAD 2019a]. Even as the pandemic disrupted countless supply chains, the port and shipping sector remained a lifeline, diligently delivering essential goods like food, medicine, raw materials, and finished products [UNCTAD 2020a]. As of 2021, this critical industry continues to operate with over 21 million vessels navigating the world's oceans or docked at ports.

However, a concerning reality emerges: for the past half-century, port and shipping operations have remained largely unchanged. Ships continue to rely on the same fossil fuels that have powered them for nearly a century, while most ports utilize traditional crane equipment for cargo and container movement. This dependence on diesel-powered vessels and machinery translates into significant environmental consequences. Emissions from these sources include carbon dioxide, nitrogen oxides, sulfur oxides, and harmful greenhouse gases.

Furthermore, the industry contributes to water pollution through the discharge of wastewater, including sewage and bilge water. Bilge water, a particularly damaging contaminant, is unclean water mixed with oil that poses a severe threat to ocean habitats. This pollution can lead to the extinction of various marine species. The problem is compounded by the improper disposal of plastics and faulty maritime equipment, often dumped overboard by ships.

The shipping industry contributes approximately 20% to all marine litter, and approximately 34% of all shipping debris ends up in the sea. Given the sector's significance to both global trade and climate change, a wide range of stakeholders, including world leaders, financiers, NGOs, and shipping firms, have focused on shipping as a crucial target for decarbonization at the U.N. Climate Change Conference (COP26) in Glasgow, Scotland. Port and Shipping activity are responsible for noise and light pollution too. CO2 and other greenhouse gas emissions from shipping vessels have been a cause for great

3.2 Background:

In an era where sustainability reigns supreme, businesses and nations across the globe are making a concerted effort to transition towards alternative fuels and clean energy sources. This green imperative extends to the port and shipping sector, a historically heavy consumer of fossil fuels and a significant contributor to global emissions. Recognizing its pivotal role in facilitating international trade, the industry has embarked on a "green voyage" by prioritizing the creation of sustainable supply chain practices.

Currently, shipping underpins a staggering 90% of international trade. To maintain this vital, unbroken supply chain, an increase in cargo vessels is inevitable. However, this growth comes at

a price – a projected rise in fossil fuel consumption and, consequently, air pollution. The shipping industry alone is responsible for approximately 940 million tons of CO2 emissions annually, translating to roughly 2.5% of the world's total. A concerning IMO study predicts that if greenhouse gases remain unregulated, emissions could soar by 90-130% of 2008 levels by 2050.

This anticipated surge underscores a critical truth: as seaborne trade scales new heights, so too do environmental and ecological concerns, alongside a growing energy demand. The optimal course of action, as outlined by Clarkson's Research (2020b) and UNCTAD (2020a, 2020b, 2020c), lies in achieving sustainable growth while safeguarding environmental, social, and economic well-being.

For port practitioners seeking to integrate sustainability into their supply chain operations, a holistic approach is paramount. This necessitates compiling all actions and measures into a single, unified tool, enabling a clear and comprehensive understanding of the implemented green strategies.

3.3 Opportunities and challenges in Indian port development:

The discourse on Indian port development delineates both its promising prospects and daunting challenges. Firstly, an overarching opportunity lies in India's remarkable economic ascent. Corresponding to the nation's rapid economic growth, its trade dynamics have also witnessed a substantial surge. From comprising a mere 17.2% of GDP in 1990, India's foreign trade burgeoned to a significant 39.9% share by 2016 (World Bank, 2019). This trajectory, peaking in 2012 at 55.6%, underscores the pivotal role of trade in India's economic landscape. A robust port infrastructure stands poised to facilitate the burgeoning trade volumes, thereby propelling further economic advancement (Wu and Lin, 2008).

Secondly, India's fortuitous geographical endowment emerges as another pivotal opportunity. Blessed with a sprawling 7,000-kilometer coastline, adorned with 12 major seaports alongside 180 minor ports, India's maritime potential is immense. Moreover, its expansive hinterland, flanked by coasts on three sides, accentuates the nation's geographical advantage in fostering maritime trade and port development. These twin opportunities stand ripe for augmentation, especially with the burgeoning developments under the Belt and Road Initiative (BRI), which beckon Indian ports into the fold of global connectivity.

Conversely, Indian port development confronts a gamut of challenges. Foremost among these is the entrenched social institution quandary. Scholars have keenly observed the infrastructural shortcomings plaguing Indian ports and the national transportation network (Kim and Nangia, 2008; Postigo, 2008). However, a comprehensive review of the literature unveils that the crux of the challenge emanates from India's social institutional fabric (Muller, 2006). Initially charting a course focused on striking a balance between economic growth and equitable distribution, India's development trajectory underwent a mid-course recalibration, accentuating wealth redistribution over economic expansion. This shift, entrenched within India's social institutional framework, poses a formidable impediment to port development ambitions (Kim and Nangia, 2008).

In essence, while the vistas of Indian port development gleam with promise, navigating the labyrinth of institutional challenges remains imperative to harnessing its full potential. Only through a concerted effort to address these underlying structural impediments can India truly realize its maritime aspirations on the global stage.

In a move towards economic liberalization that began in the late 1970s, the Indian government has opened various sectors, including transportation, to private investment from both domestic and foreign sources. The Jawaharlal Nehru Port Trust (JNPT), established in 1993, stands as a pioneering example of privatization within India's seaport system (Bennett, 1995; Monie, 1995). However, despite these reforms, a significant hurdle remains: the reluctance of private investors to commit large sums to Indian seaports due to concerns surrounding the country's extensive social safety net.

While delaying privatization entirely would be unwise, a cautious approach is necessary. Potential solutions include negotiating with labor unions and introducing novel commercial approaches. Additionally, the Major Ports Trust Act (MPTA) has been identified as a major obstacle to successful privatization (Haralambides and Behrens, 2000). In the Indian context, legislative and institutional reforms, rather than solely focusing on physical infrastructure development, are crucial for long-term success. However, achieving such changes will likely be a time-consuming process. The disappointing results of past technical assistance provided by international organizations and foreign countries highlight this very point. The deeply entrenched social fabric of India presents a unique challenge that cannot be addressed solely through infrastructure upgrades.

The second challenge in Indian port development underscores the existing disparities among its major ports, exacerbating the overall impediments to progress. Ghosh and De's findings highlight a glaring inequality among these ports, with discernible stagnation on the east coast, in stark contrast to the relatively more robust performance of ports situated on the west and south coasts. Seeking to elucidate the causal link between port performance and traffic volume, De and Ghosh conducted an in-depth analysis utilizing Indian statistical data. Their research underscores a critical insight: enhanced port performance, characterized by superior efficiency and infrastructure, correlates positively with increased port traffic. However, this correlation is undermined by the prevailing poor performance of the majority of Indian ports.

The overarching imperative, therefore, lies in bolstering the capacities of both major and minor ports across India to accommodate the escalating trade volumes. Furthermore, there exists a compelling necessity to cultivate a global or, at the very least, a regional hub port that can serve as the linchpin for the nation's maritime aspirations. The exemplars of Singapore and Shanghai serve as pertinent benchmarks, demonstrating the transformative potential of establishing such pivotal maritime hubs. By emulating their successes and strategically leveraging India's strategic geographical position, the nation can endeavor to catalyze its port development agenda, fostering enhanced efficiency, competitiveness, and global connectivity.

The third challenge confronting Indian port development pertains to the persistent imbalance between import and export trade, with imports maintaining a dominant position vis-à-vis exports. This disparity has widened notably over the past decade, signaling a structural imbalance in India's trade dynamics.

An economy skewed towards imports poses inherent constraints on port development initiatives. In contrast, an export-oriented economic model not only generates greater income for a nation but also exerts a positive ripple effect on overall economic development. However, India's import-centric economic trajectory poses a substantive hurdle to port development endeavors. The resultant lower trade volumes, relative to an export-oriented paradigm, impede the realization of the full potential of India's port infrastructure.

Addressing this challenge necessitates a multifaceted approach, encompassing policy interventions aimed at rebalancing the import-export equation, incentivizing export-oriented industries, and fostering a conducive environment for international trade. By recalibrating its trade policies and

augmenting efforts to cultivate export-driven sectors, India can pivot towards a more balanced trade landscape, thereby unlocking the latent potential of its port infrastructure to catalyze broader economic growth and development.

The fourth challenge looming over Indian port development is emblematic of a broader infrastructural deficiency: the acute shortage of power. This deficit not only casts a shadow over port development endeavors but also reverberates across the entire economic landscape of the nation.The Indian government had set forth an ambitious target to ensure universal access to electricity throughout the country by March 2012. Despite making significant strides in augmenting power generation capacity, evidenced by a surplus as of 2018, India grapples with systemic inadequacies in distribution infrastructure. Shockingly, over 300 million Indian citizens still find themselves bereft of access to electricity, underscoring the yawning chasm between aspiration and reality.

Addressing this formidable challenge demands a concerted effort to bolster both power generation and distribution infrastructure, alongside targeted interventions aimed at expanding access to electricity for marginalized communities. Only through such holistic measures can India surmount the impediments posed by its power deficit, thereby unleashing the full potential of its ports as engines of economic growth and prosperity.

3.4 GREEN SHIPPING & PORTS:

Environmental effects arise at every stage of a terminal's life cycle, including port development, building, operation, expansion, and closure or termination. When it comes to landside operations that link inland transportation, intermodal connections and traffic congestion have a negative environmental impact that leads to things like air pollution. Depending on the mode selections made and the associated costs and transit times requested by shippers, these environmental effects can differ. Other port services that affect the environment include distribution and warehousing, industrial and semi-industrial activity, and others.

Terminal activities are one source of seaport environmental impact, which can be divided into various types, namely:

- Ship dock air emissions and terminal handling equipment (such as cranes and yard equipment).

- Noise caused by cargo handling procedures.
- The environmental consequences and potential congestion associated with a landside barge, rail, and truck operations.

3.4.1 Emission Control Through:

- By reducing vessel waiting times and turnaround times, for example, by synchronizing and integrating the nautical chain with optimized vessel traffic management systems. Implement green port dues and voluntary green shipping initiatives to encourage operators to enhance their ships' environmental performance.

- Use Cold Ironing, Shore Power Supply, or Alternate Marine Power (AMP) at berth, where seagoing boats and barges use shore power for auxiliary engines instead of bunker fuel. Cold ironing is currently most common in the cruise liner and ferry industries. There are issues with the investment cost (port and ship), the distribution of these costs among different stakeholders, and the break-even cost in comparison to bunker fuel.
- Encourage the use of LNG as a marine fuel. Investing in LNG bunkering infrastructure in ports has exploded in recent years. Several public port authorities, often in close collaboration with industrial actors, are proactive in facilitating LNG as a marine fuel.

3.5 INDIAN PORTS AND GREEN SHIPPING:

In a bold stride towards environmental sustainability, Indian ports have set an ambitious target to slash carbon emissions by 30% per ton of cargo handled by 2030. This commitment is further solidified by India's pioneering role in the IMO Green Voyage 2050 initiative, making it the first nation to pilot a Green Shipping program.

The cornerstone of these Green Port initiatives lies in multifaceted infrastructure advancements. This includes the acquisition of cutting-edge equipment for environmental pollution monitoring, alongside dust suppression systems to minimize air contamination. Furthermore, robust sewage and wastewater treatment plants will be established to ensure proper waste management. Garbage disposal systems will be implemented for both ports and the visiting ships, complemented by shore reception facilities that effectively handle ship-generated waste.

The transition towards clean energy sources is another crucial pillar of the Green Port strategy. This will be achieved through the establishment of renewable energy projects to power port operations and by providing shore power to ships docked at berths, thereby eliminating their reliance on polluting onboard generators. Additionally, all ports will be equipped with Tier-1 oil spill response capabilities to mitigate the risk of environmental disasters.

The initiative extends beyond infrastructure upgrades, encompassing a holistic approach to environmental stewardship. Proactive measures will be taken to improve harbor water quality, while sustainable practices will be integrated into the design, development, and operation of port terminals. Efforts to increase green cover within port premises will further enhance the environmental well-being of these crucial maritime hubs.

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Haldia -First "Green Port" of India

It is the first Green Port in the country after a bio-diesel dispensing unit was inaugurated in it. Haldia Dock Complex, Part of Syama prasad Mookerjee Port, will Start using Biodiesel to run its railway engines, trucks, and other vehicles.

Cochin Port- Hydrogen-Fuelled EV

The CSL has partnered with KPIT Technologies Limited and Indian developers in the areas of hydrogen fuel cells and powered trains.

The hydrogen fuel cell vessel based on low-temperature Proton Exchange Membrane Technology (LT-PEM) is expected to cost around Rs 17.50 crore of which 75% would be funded by the Government of India.

JNPA (Jawaharlal Nehru Port Authority):

JNPA, India's largest container port, has introduced various green measures, such as using solar power to reduce grid electricity use, installing LED lighting for energy efficiency, and using hybrid vehicles for port operations.

Chennai Port:

To reduce pollution, the port has erected a 1 MW solar power plant, and electric vehicles are utilised for internal transportation. The port also launched a waste-to-energy project, which turns the port's solid waste into energy.

Mundra Port:

Has invested in wind and solar energy projects, generating around 15% of the port's electrical demands from renewable sources. To cut energy use, the port also employs electric cars and has installed energy-efficient lighting.

Visakhapatnam Port Authority:

Has developed a 10 MW solar power plant, which meets around 30% of the port's electrical needs. In addition, the port uses electric vehicles for internal mobility and has taken steps to limit water use and garbage generation.

3.6 PORT SUSTAINABILITY:

In recent years, Indian ports have been actively working towards sustainability and lowering their environmental footprint. Some of the important activities and actions implemented by Indian ports to promote sustainability are as follows:

Adoption of Green Energy: A key pillar of this strategy is the adoption of green energy. Many ports, like the Jawaharlal Nehru Port Trust (JNPT) with its 25 MW solar plant, are replacing fossil fuels with renewable sources like solar and wind power. This shift has resulted in substantial reductions in CO2 emissions, with JNPT alone saving an estimated 30,000 tonnes annually.

Environmentally Friendly Port Operations: Environmentally friendly operations are another area of focus. Several ports are implementing initiatives such as utilizing electric vehicles, transitioning to LED lighting, and adopting sustainable waste management practices. The Chennai Port Trust's "zero-waste policy" exemplifies this commitment, ensuring all port-generated waste is recycled or responsibly disposed of.

Sustainable Infrastructure: Sustainable infrastructure development is also playing a crucial role. Ports are investing in green buildings, rainwater harvesting systems, and environmentally

conscious dredging practices. The V.O. Chidambaranar Port Trust's green facility, equipped with solar panels, energy-efficient lighting, and water-saving features, serves as a prime example.

Adoption of Clean Fuel: Furthermore, Indian ports are actively promoting the use of cleaner fuels like liquefied natural gas (LNG) to minimize their environmental impact. The Cochin Port Trust's implementation of LNG bunkering services provides ships with this cleaner fuel option, thereby reducing pollution levels.

Environmental Regulations: Finally, stringent environmental regulations are a cornerstone of this sustainability drive. Indian ports are required to adhere to various standards, including those set forth by the International Maritime Organization (IMO) to minimize greenhouse gas emissions. Additionally, all expansion and development projects undertaken by Indian ports must secure environmental approvals and undergo environmental impact assessments. These comprehensive measures underscore India's commitment to transforming its ports into eco-conscious hubs.

3.7 LIMITATIONS & CHALLENGES:

Technical Limitations

One significant challenge lies in the compatibility of existing port infrastructure with green technologies. Retrofitting existing ports for shore power connections requires significant investment in upgrading electrical grids and modifying berths to accommodate power connections for docked vessels. A 2019 study by the World Bank estimated that the global investment required for shore power infrastructure could reach USD 100 billion by 2030 Similarly, integrating waste-to-energy plants within ports necessitates careful consideration of space constraints and potential air and water emission concerns.

Furthermore, a skilled workforce is essential for operating and maintaining new technologies. Upskilling existing port personnel and attracting qualified individuals to manage these systems require robust training programs and competitive salaries. A 2021 report by the International Transport Workers' Federation (ITF) highlighted the skills gap in the maritime sector regarding green technologies, emphasizing the need for targeted training initiatives

Economic Limitations

The initial investment costs associated with sustainable practices pose a significant economic limitation. Clean technologies, such as shore power connections and electric cargo handling equipment, typically have higher upfront costs compared to conventional options. While long-term operational cost savings from reduced fuel consumption are projected, the payback period for these investments can be long. This can be a deterrent for port authorities, particularly for public sector ports with limited financial resources.

Furthermore, attracting private sector investment requires a clear demonstration of the economic viability of sustainable practices. Uncertainty regarding long-term returns on investment and potential regulatory changes can discourage private participation. Developing robust economic models and establishing clear long-term goals for emission reduction can incentivize private sector involvement.

Social Considerations

Transitioning to sustainable practices can present challenges for the workforce. The adoption of automation and cleaner technologies might lead to job displacement in specific areas, particularly for those involved in traditional fuel handling operations. Effective reskilling and retraining programs are crucial to mitigate such impacts and ensure a smooth transition for the existing workforce.

Additionally, potential community concerns regarding the implementation of certain sustainable practices need to be addressed. Waste-to-energy plants, despite their potential for waste reduction and energy generation, can raise concerns about air and water pollution. Transparent communication with local communities, coupled with robust environmental impact assessments and stringent emission control measures, are essential to garner public support.

Political Hurdles

The effectiveness of environmental regulations plays a crucial role in driving sustainable practices. While initiatives like the National Green Shipping Policy and the Smart Ports initiative promote cleaner technologies and infrastructure, enforcing these regulations can be challenging. Limited

capacity within regulatory agencies and a lack of stringent penalties for non-compliance can hinder effective implementation.

Furthermore, political will and stakeholder collaboration are essential for overcoming these challenges. Securing long-term political commitment to environmental sustainability within the maritime sector requires a clear understanding of the long-term benefits. Effective collaboration between government agencies, port authorities, shipping lines, labor unions, and local communities is crucial for developing a comprehensive and balanced approach that prioritizes environmental protection without neglecting economic and social considerations.

Other than these, several ither challenges exists too-

- **Carbon Intensity**: Indian ports contribute to greenhouse gas emissions through various activities such as cargo handling, transportation, and energy consumption. Reducing carbon intensity is a critical challenge.
- **Air and Water Pollution**: Ports generate air pollution from diesel-powered machinery, while water pollution occurs due to ballast water discharge, oil spills, and waste disposal.
- **Outdated Infrastructure**: Many Indian ports have outdated infrastructure that lacks energy-efficient designs. Upgrading existing facilities to meet modern sustainability standards is challenging.
- **Limited Technology Adoption**: The adoption of green technologies (such as electric cranes, renewable energy sources, and energy-efficient lighting) faces resistance due to cost constraints and lack of awareness.
- **Policy Gaps**: Although the Indian government has announced Green Ports policies, there are gaps between policy objectives and implementation. Harmonizing regulations across different ports remains a challenge.
- **Monitoring and Enforcement**: Ensuring compliance with environmental regulations requires robust monitoring mechanisms and strict enforcement.
- **Coordination**: Ports involve multiple stakeholders, including logistics providers, terminal operators, shipping lines, and local communities. Coordinating efforts for sustainable practices is complex.

- **Balancing Interests**: Balancing economic interests with environmental concerns is a delicate task. Some stakeholders prioritize profit over sustainability.

3.8 POTENTIAL SOLUTIONS:

3.8.1 Green Port Certification

- The Indian government should establish a comprehensive certification system for major ports, similar to the International EcoPorts certification.
- Certification would incentivize ports to adopt sustainable practices by recognizing their efforts. It would also enhance their reputation globally.
- As of now, only a few Indian ports have received Green Port certification. For instance, the Jawaharlal Nehru Port Trust (JNPT) in Mumbai achieved this certification in 2015.

3.8.2 Energy Efficiency Measures

- Ports should prioritize energy-efficient technologies and practices.

  Examples:

  Cold Ironing (Shore Power): Implement shore power facilities to allow ships to turn off their engines while docked, reducing emissions.

  LED Lighting: Replace conventional lighting with energy-efficient LED lights to reduce electricity consumption.
  Solar Power: Install solar panels on port buildings and warehouses to generate renewable energy.

- According to reports from the Jawaharlal Nehru Port Authority (JNPA), energy consumption accounts for a significant portion of port operational costs. Implementing energy-efficient technologies can lead to substantial savings and reduce the carbon footprint.

3.8.3 Ballast Water Treatment

- Develop and enforce stringent regulations for ballast water discharge to prevent the spread of invasive species.
- India ratified the International Maritime Organization's Ballast Water Management Convention in 2020, emphasizing the need for effective ballast water treatment.

3.8.4 Oil Spill Preparedness and Response

- Ports should have robust oil spill response plans, including equipment, training, and coordination with relevant agencies.
- The Chennai Port Trust has invested in oil spill response equipment and training programs.

3.8.5 Stakeholder Participation:

- Involve local communities, NGOs, and environmental groups in port planning and decision-making processes.
- The Mormugao Port Trust in Goa has initiated community engagement programs to address concerns related to pollution and livelihoods.

3.8.6 Biodiversity Conservation

- Protect and restore coastal ecosystems within port areas.

  Examples:
  - Establish mangrove forests to act as natural buffers against storm surges and provide habitat for marine life.
  - If applicable, restore damaged coral reefs near ports.

- The Cochin Port Trust has undertaken mangrove afforestation projects along its coastline.

3.8.7 Collaboration with Research Institutions

- Partner with universities and research institutes to study environmental impacts and develop innovative solutions.
- The Visakhapatnam Port Trust collaborates with Andhra University for research on coastal ecology and pollution control.

3.8.8 Technological Innovations

- Invest in emerging technologies such as electric cranes, automated container handling, and real-time environmental monitoring systems.
- The Paradip Port Trust has introduced electric rubber-tired gantry cranes to reduce emissions.

3.9 Implications for the Shipping Industry

The adoption of environmental sustainable practices in Indian major ports has significant implications for the shipping industry. Let's explore these implications in detail:

3.9.1 Cost Efficiency and Competitiveness

- Sustainable practices, such as using shore power (cold ironing) and transitioning to cleaner fuels, can reduce fuel consumption. Lower fuel costs directly impact shipping companies' operational expenses.
- Ports that prioritize sustainability become attractive to shipping lines. Ports with efficient operations and reduced environmental impact gain a competitive edge, attracting more vessels and cargo.

3.9.2 Regulatory Compliance and Reputation

- The shipping industry operates globally, adhering to international regulations. Ports that comply with environmental standards (e.g., IMO's MARPOL Annex VI) facilitate smoother operations for shipping companies.
- Ports known for sustainable practices enhance their reputation. Shipping companies prefer reliable, environmentally conscious ports to avoid delays, penalties, and negative publicity.

3.9.3 Emission Reduction and Air Quality

- The International Maritime Organization (IMO) aims to reduce greenhouse gas emissions from shipping by 50% by 2050. Ports that contribute to emission reduction help the industry achieve these targets.

- Cleaner air around ports improves the health of port workers, nearby communities, and crew members. Reduced emissions lead to fewer respiratory illnesses and better overall well-being.

3.9.4 Efficient Cargo Handling and Turnaround Times

- Ports investing in energy-efficient cranes, conveyors, and handling machinery improve cargo handling efficiency. Faster turnaround times benefit shipping companies by reducing vessel idle time.
- Sustainable practices enable just-in-time arrivals, minimizing waiting time for ships. Efficient cargo handling reduces congestion and optimizes vessel schedules.

3.9.5 Risk Mitigation and Resilience

- Ports that consider climate change impacts (e.g., sea-level rise, extreme weather events) in their infrastructure planning enhance their resilience. Shipping companies prefer ports that can withstand disruptions.
- Sustainable practices reduce the risk of environmental accidents (e.g., oil spills) during natural disasters. Preparedness and response plans minimize damage to vessels and cargo.

3.9.6 Collaboration and Innovation

- Ports collaborating with shipping lines, logistics providers, and industry associations foster innovation. Joint efforts lead to the development of sustainable technologies and best practices.
- Ports investing in green technologies (e.g., electrification, automation) drive innovation. These advancements benefit the entire shipping ecosystem.

CHAPTER – 04

4.1 Analysis:

Indian ports are making tremendous efforts to improve their sustainability and reduce their environmental effect. Some of the important steps performed by Indian ports towards sustainability include the use of green energy, eco-friendly port operations, the creation of sustainable infrastructure, the use of clean fuel, and compliance with environmental standards. These measures not only assist Indian ports become more ecologically responsible, but they also contribute to the country's overall sustainable growth.

The first step is to achieve the SDGs. Visualizing, quantifying, and optimizing GHG emissions will help to reduce their negative environmental impact. This will contribute to the achievement of SDG 13: Take immediate action to combat climate change and its consequences.

Second, better working circumstances. It is envisaged that the PiChain architecture will improve workers' working circumstances. For example, AI-guided ideal delivery routes will reduce driver stress by lowering waiting time. Furthermore, logistics personnel will be able to profit from advanced visibility and conduct their regular tasks more independently. This will help to achieve SDG Goal 8: Promote inclusive, long-term economic growth, full and productive employment, and decent work for all.

4.1.1 CO2 Emissions from Indian Shipping and Initiatives for Green Shipping:

There is consistently about from ships less than 5000 20% of total emissions GT and those of 5000 GT & above and certified as RSV or ICV. The total emissions from Indian shipping is less than 5 Million M-T and that from those on International voyages is about 2.56 Million MT. In 2018, as per IMO 4th GHG Study, International shipping emitted 740 M-MT of CO2 emissions and based on this data, Indian international shipping contribution is about 0.3%. CO2 Emission per Ship (Million Tones /Ship) has remained at about 0.0056. Annual carbon emissions in Metric-Tones/GT has remained same at about 0.495 in 2022 and 2021 and when compared to 2019 (leaving 2020 due to impact of COVID-19) has reduced from , that is, about 3.3%. The Annual Carbon Emissions per Deadweight (Tons of Carbon Emissions /Deadweight) has remained about 0.3 in 2022 and 2021 and when compared to 2019 (leaving 2020 due to impact of COVID-19) has reduced from 0.308 to 0.297, that is, about 9.5%.

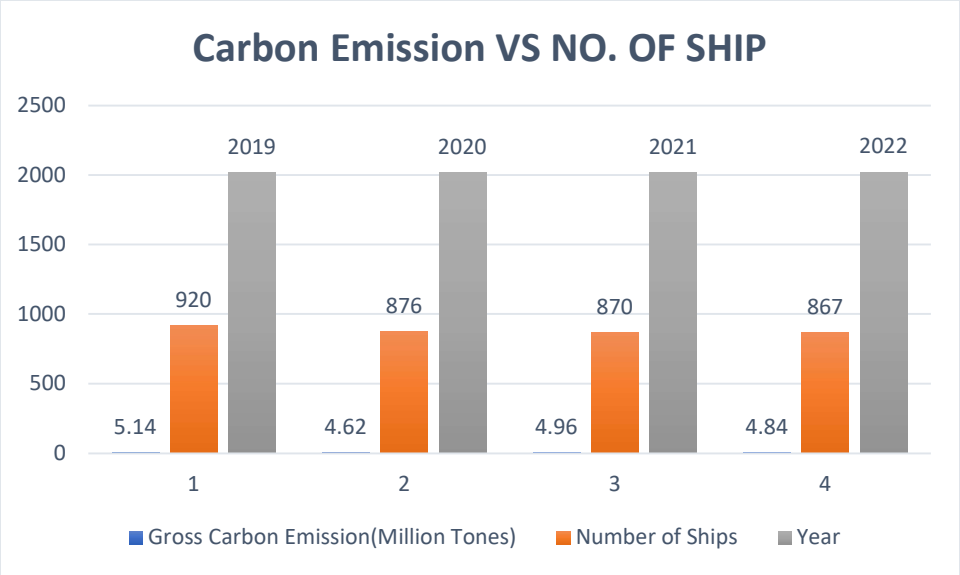

Figure 2: Carbon emission vs No. of Ship (Source : Marine Environmental Management Report 2023)

According to the graph, the number of ships has increased slightly over the four years while gross carbon emissions have fluctuated. In 2019, there were 4.62 billion tons of gross carbon emissions and 5.14 ships. In 2022, there were 4.84 billion tons of gross carbon emissions and 867 ships.It is important to note that correlation does not equal causation. The fact that the number of ships and gross carbon emissions appear to be related on this graph does not necessarily mean that an increase in the number of ships causes an increase in gross carbon emissions. There could be other factors at play that are not shown in this graph

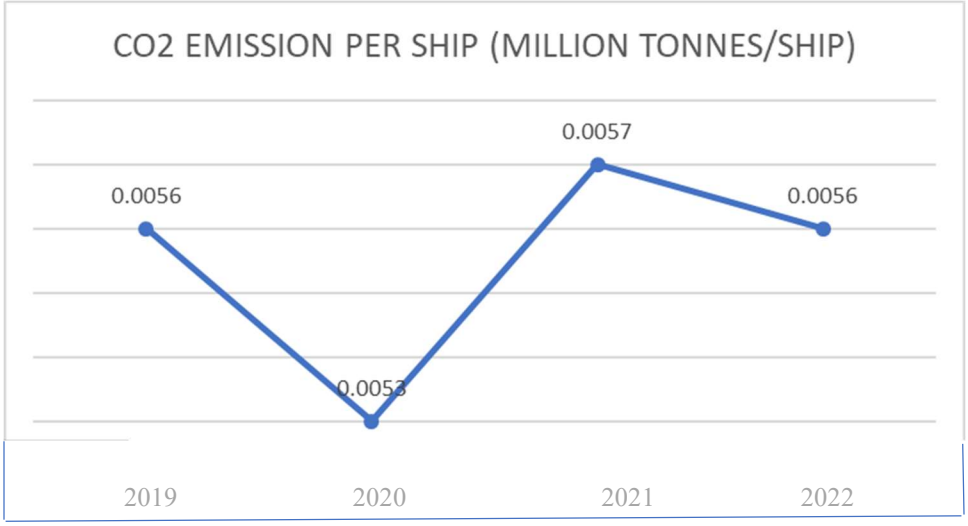

Figure 3: CO2 Emission per ship (Source: Marine Environmental Management Report 2023)

The carbon emissions per ship appear to fluctuate slightly over the four years. In 2019, the average carbon emission per ship was 0.0057 million tonnes/ship. In 2022, it was 0.0053 million tonnes/ship.

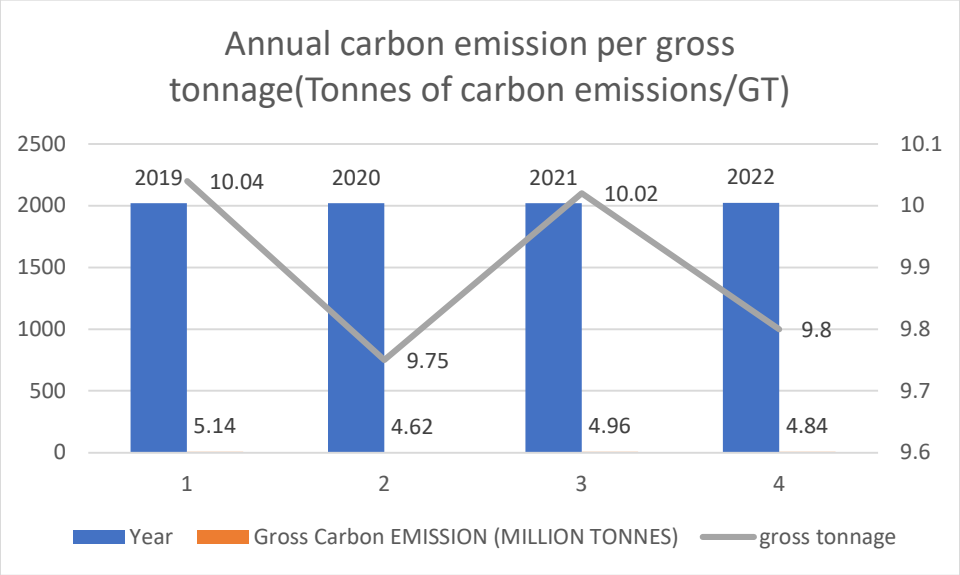

Figure 4: Representing Annual carbon emission per gross tonnage (Source: Marine Environmental Management Report 2023)

In 2015, the annual carbon emission per gross tonnage was 9.6 tonnes. In 2022, it was 10.1 tonnes. It is important to note that the data points for 2019-2022 are all very close together, and it is difficult to say for certain whether this is a significant upward trend. More data points would be needed to confirm this trend.

Here are some other factors that could affect carbon emission per gross tonnage:

- The size and type of ships: Larger ships and ships that use less efficient fuels are likely to emit more carbon per gross tonnage.
- The distance that ships travel: Ships that travel longer distances are likely to emit more carbon per gross tonnage.
- Regulations on carbon emissions: Regulations on carbon emissions may have reduced emissions per gross tonnage in recent years.

Without more information about the data, it is difficult to say for certain what is causing the apparent increase in carbon emission per gross tonnage.

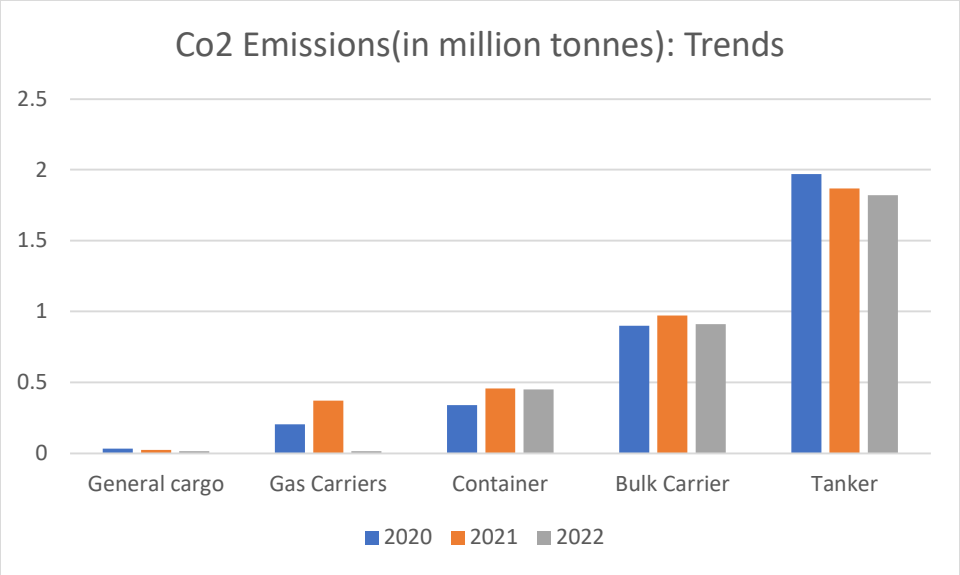

Figure 5: Representing the carbon emission in ports by different types of vessels (Source: Marine Environmental Management Report 2023)

CO2 emissions from all ship types increased between 2020 and 2022. General cargo ships emitted the most CO2 in all three years, with emissions of 1 million tonnes in 2020, 1.1 million tonnes in 2021 and 1.2 million tonnes in 2022. Tankers emitted the second-highest amount of CO2 in each of the three years. In 2020, tankers emitted 0.7 million tonnes, in 2021 they emitted 0.8 million tonnes and in 2022 they emitted 0.9 million tonnes.

4.1.2 Efforts by Government of India to Reduce Emissions from Indian Ships:

There are a number of Policy initiatives undertaken by GOI to transit Indian Shipping and Ports towards a greener regime. These include:

National Green Hydrogen Mission.

The National Green Hydrogen Mission spearheads India's ambitious goal of becoming a global leader in the production, usage, and export of green hydrogen and its derivatives. This initiative aligns perfectly with India's vision of "Aatmanirbhar Bharat" (self-reliant India) powered by clean energy, and serves as a potential beacon for the global transition towards clean energy. The Mission holds immense potential for decarbonizing the Indian economy, reducing dependence on

imported fossil fuels, and establishing India as a technological and market frontrunner in the green hydrogen domain.

Playing a pivotal role in this mission is the Ministry of Ports, Shipping and Waterways (MoPSW). They are tasked with spearheading India's green hydrogen and derivative export capabilities. This entails facilitating the development of crucial infrastructure, including storage bunkers, port operations equipment specifically designed for green hydrogen, and dedicated refuelling facilities. Furthermore, MoPSW is entrusted with driving the adoption of hydrogen and its derivatives, such as ammonia and methanol, as clean fuel sources for maritime vessels. Ultimately, the Ministry aspires to transform India into a central hub for refueling with green hydrogen and its derivatives.

Shore Power Supply to Ships:

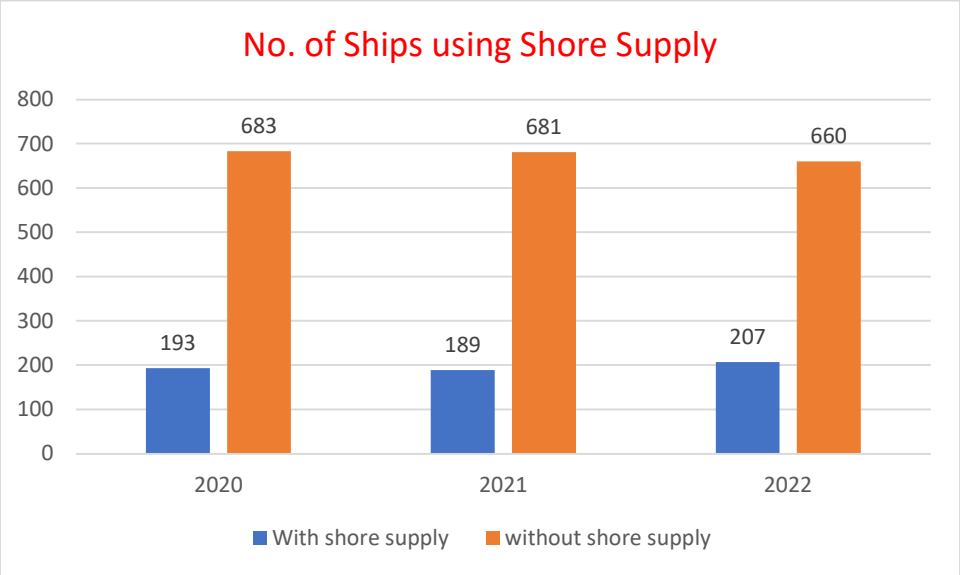

Figure 6: Representing numbers of ships using Shore Supply (Source: Marine Environmental Management Report 2023)

There is a continuously increase in number of ships using shore power with an increase of about 9.5% increase in number of ships in 2022 compared to 2021.

Ports that have reported supply of Shore Power:

Port	Ship Type being supplied Shore Power	Maximum Power which can be supplied	Voltage and Frequency of Supply
Paradip port Authority	Port owned/Hired Tugs/Floating crafts	Sufficient Power for small vessels	415 V, 50 Hz, 3 Phase
VOC Port Authority	Tug, Pilot Launch, Patrol Boat, small crafts and other ships: store power supply provided at all berths inside VOCPA but provided on their request	1MVA or 1000 KVA	415V, 50Hz, 3 Phase
	All other commercial missiles vessels at VOC 2&3 Berths: Shore power supply has been provided to sips on their request since 2017. However, not made as mandatory	500 KVA	415 V, 50 Hz Or 60 Hertz as required, 3 phase
New Mangalore Port Authority	Indian Coast Guard vessels, Port Tugs and Pilot launches only	150 Kw	415 V, 50 Hz, 3 phase
Chennai Port Authority	Naval Vessel/ Custom vessels And Port tugs and launches	150 Kw	415 V, 50 Hz, 3 phase
Kamarajar Port Limited	Tugs, Pilot Boats , Mooring Boats	50 KW	415 V, 50 Hz, 3 phase
Mumbai Port Authority	Port Crafts	150 KW	415 V, 50 Hz
Jawaharlal Nehru Port Authority (JNPA)	All container Ships & feasible oil Tankers ships	7.5 MW	6.6 KV at 50/60 Hz both
Murmugao Port Authority	Tug Boats	(i) Breakwater berths: 200KVA &500 KVA	440v, 50Hz
Coachin Port Berth	Tugs, Barges, Pilot Boats etc.	125 KW	415 V, 50 Hz, 3 phase

Table-1 List of ports having shore supply & their capacity (Source: Marine Environmental Management Report 2023)

Harit Sagar of Green Port Guidelines:

The Harit Sagar of Green Port guidelines issued in 2023 has brought forward the target date of all the above initiatives in order to reduce carbon emissions in port operations faster and create sustainable ports. It aims to:

- Equipping all major ports to supply shore power to all ships, including those engaged in import-export activities (EXIM), by 2025.
- Exploring the installation of desalination plants, where not already present, as an alternative to ground or surface water sources. This future-proofed approach would facilitate the production of green hydrogen
- Establishing green ammonia bunkering and refueling facilities at all major ports by 2035. This cleaner fuel option will significantly reduce emissions from maritime operations.
- Encouraging a phased retrofitting of port craft, including tugs, pilot boats, mooring boats, and survey vessels, to enable them to utilize cleaner and greener fuels such as green ammonia, green hydrogen (through fuel cells), and green methanol.

4.1.3 Analysis based on Questionnaire:

- To the question of do they believe environmental sustainability is important for the ports & how critical is environmental sustainability for the long term success of major ports.94% people responded that they believe environmental sustainability is important for the operation of major ports & 47.6% that means majority of the people believe that environmental sustainability is extremely important for the long term success of Indian major ports.

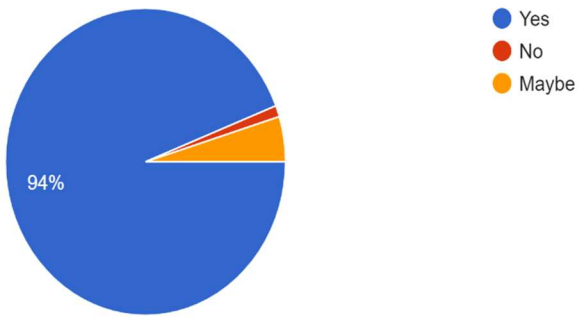

Figure 7: Response to the importance of environmental sustainability in ports. (Source- Primary data)

- To the question are they aware of any specific environmental initiatives implemented at Indian Major ports if yes then specify. In response 85% people are aware of environmental initiatives implemented at Indian major ports and they have respond according to their awareness like Waste management programs, Renewable energy projects, Pollution control measures & Habitat restoration efforts.

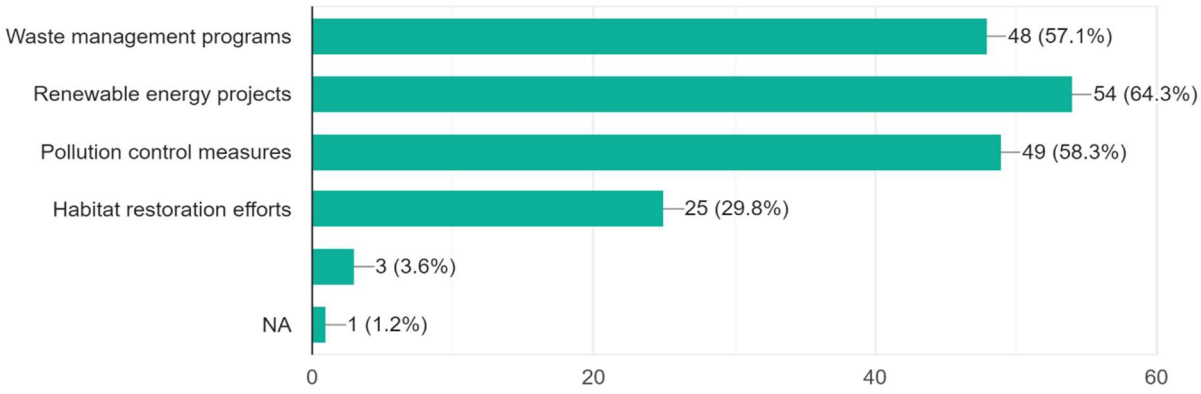

Figure 8 : Response to the different environmental initiatives(Source- Primary data)

- To the question of how much effective is 'Utilization of shore power connection for docked vessels' is in perspective of environmental sustainability. 36% of people responded that they believe that utilization of shore power connection for docked vessels is way effective and around 28% of people think that it is moderately effective towards the goal of environmental sustainability.

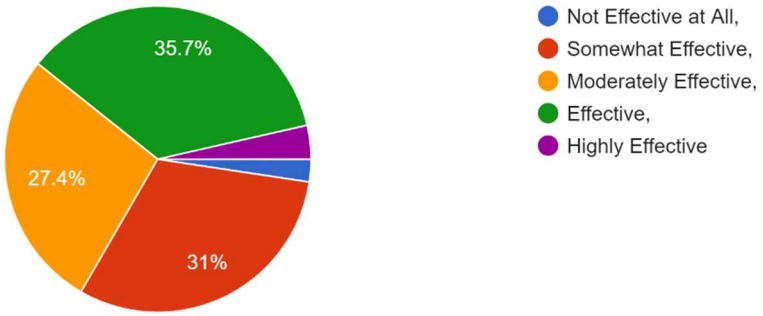

Figure 9: Response to the effectiveness of utilization of shore power connection(Source- Primary data)

- To the Questions related to energy efficiency practices like upgrading port infrastructure with energy efficient technologies, utilizing renewable energy sources (e.g. Solar, wind) to power port operation & can sustainable practices improve operational efficiency of ports around 67% people responded positively which means these practices are really effective in terms of improvement of operational efficiency of the ports and the level of disagreement is too low that means most of the respondent who are associated with shipping and port industry are active player in the improvement in the industry.

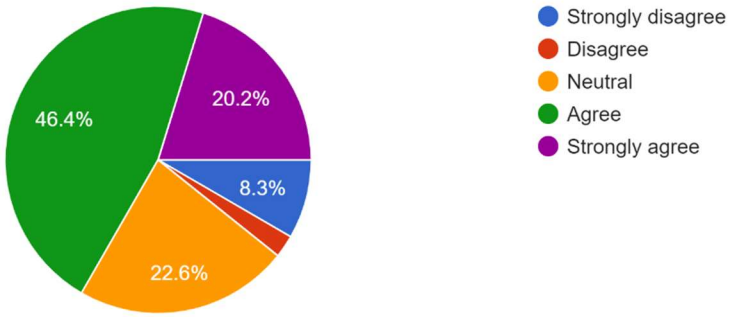

Figure 10: Response to the effectiveness of energy efficiency practices. (Source- Primary data)

4.2 Findings:

- Encouraging the adoption of shore power facilities, allowing ships to connect to the grid while docked, thereby reducing emissions from onboard generators.
- Replacement of conventional lighting with energy-efficient LED lights across port facilities. JNPT has adopted LED lighting across its terminals, resulting in significant energy savings.
- Investment in solar panels to generate renewable energy within port premises.
- Indian major seaports prioritize economic sustainability. Factors such as revenue generation, cost-effectiveness, and efficient resource utilization contribute to their economic performance.
- The ports have adopted various measures to mitigate adverse environmental impacts, such as reducing air and water pollution, conserving energy, and managing waste effectively.
- Investments in port infrastructure, attracting foreign investment, and supporting economic growth are essential aspects.
- Ports play a crucial role in environmental conservation. Sustainable practices include minimizing land use, avoiding environmental destruction during dredging, and maintaining water quality.
- Environmental pollution prevention and adherence to environmental regulations are critical for sustainable port operations.
- Effective collaboration with stakeholders (such as government agencies, local communities, and industry partners) is crucial for sustainable port development.
- Engaging stakeholders in decision-making processes ensures a holistic approach to sustainability.
- Policymakers can modify existing policies to align with Sustainable Development Goals (SDGs) and enhance maritime sustainability.
- Indian major ports have made significant progress in implementing sustainable practices in line with national and international environmental policies and regulations.
- The ports have adopted various measures to mitigate adverse environmental impacts, such as reducing air and water pollution, conserving energy, and managing waste effectively.
- The Environmental Impact Assessment (EIA) process is followed diligently to assess potential environmental risks associated with port development projects.

- Indian major ports have implemented energy conservation measures to reduce their carbon footprint.
- Several ports have adopted renewable energy sources, such as solar power, wind energy, and biomass, to meet their energy requirements.
- Energy-efficient lighting systems, equipment, and machinery are being used to reduce energy consumption.
- Effective waste management practices have been implemented in Indian major ports to minimize the impact on the environment.
- Ports have established waste treatment and disposal facilities, including waste segregation, recycling, and proper disposal of hazardous waste.
- Initiatives like composting organic waste, promoting the use of eco-friendly packaging, and implementing waste reduction strategies have been successful in reducing waste generation.
- Indian major ports have taken measures to conserve water resources and control water pollution.
- Ports have implemented wastewater treatment plants to treat and recycle wastewater before discharge, ensuring compliance with regulatory standards.
- Efforts are being made to reduce pollution from ship operations, such as the use of low-sulfur fuels and implementing ballast water management practices.
- Many ports have established mangrove conservation programs, creating and restoring mangrove forests to protect coastal ecosystems.
- Environmental impact assessments are conducted to identify potential impacts on marine life and take necessary measures to mitigate them.
- Indian major ports actively engage with stakeholders, including local communities, NGOs, and government agencies, to ensure transparency and collaboration in environmental decision-making.
- Stakeholders are actively involved in environmental monitoring and review processes, contributing to the overall effectiveness of sustainable practices.
- Regular consultations and public hearings are conducted to address concerns related to environmental sustainability.
- Indian major ports have recognized the importance of conserving biodiversity in their vicinity.

- Many ports have established mangrove conservation programs, creating and restoring mangrove forests to protect coastal ecosystems.
- Rainwater harvesting systems are in place to collect and utilize rainwater for various port operations.

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5.1 Conclusion

The study on environmental sustainable practices in Indian major ports has shed light on the significant progress made in mitigating adverse environmental impacts and promoting sustainable development. The findings have highlighted the efforts made by the ports in adopting environmentally friendly policies, implementing energy conservation measures, managing waste effectively, conserving water resources, and protecting biodiversity. One of the key findings of the study is the adherence to environmental policies and regulations by Indian major ports. The ports have demonstrated a commitment to aligning their operations with national and international environmental standards. The Environmental Impact Assessment (EIA) process has been instrumental in identifying potential environmental risks associated with port development projects and implementing necessary measures to mitigate them.

Energy conservation measures have been successfully implemented in Indian major ports, reducing their carbon footprint. The adoption of renewable energy sources, such as solar power, wind energy, and biomass, has significantly contributed to reducing dependence on fossil fuels. The use of energy-efficient lighting systems, equipment, and machinery has also played a crucial role in minimizing energy consumption. Waste management practices in Indian major ports have been effective in minimizing the impact on the environment. Ports have established waste treatment and disposal facilities, promoting waste segregation, recycling, and proper disposal of hazardous waste. Initiatives like composting organic waste and promoting eco-friendly packaging have further contributed to reducing waste generation.

Water conservation and pollution control measures have been implemented to safeguard water resources and minimize water pollution in Indian major ports. Rainwater harvesting systems have been instrumental in collecting and utilizing rainwater for various port operations. Wastewater treatment plants have been established to treat and recycle wastewater before discharge, ensuring compliance with regulatory standards. Efforts to reduce pollution from ship operations, such as the use of low-sulfur fuels and ballast water management practices, have also contributed to water pollution control. Biodiversity conservation has been recognized as a crucial aspect of sustainable development in Indian major ports. The establishment and restoration of mangrove forests have played a significant role in protecting coastal ecosystems and preserving marine biodiversity.

Environmental impact assessments have helped identify potential impacts on marine life and implement necessary measures to mitigate them.

Stakeholder engagement has been a key element in promoting environmental sustainability in Indian major ports. Regular consultations and public hearings have ensured transparency and collaboration in environmental decision-making. The active involvement of stakeholders, including local communities, NGOs, and government agencies, has contributed to the overall effectiveness of sustainable practices. While significant progress has been made, there are still challenges that need to be addressed. Inadequate infrastructure, limited resources, and the need for continuous improvement in environmental monitoring pose ongoing challenges. However, these challenges also present opportunities for further innovation and investment in sustainable practices. The implementation of emerging technologies, such as the Internet of Things (IoT) and Artificial Intelligence (AI), can enhance the efficiency and effectiveness of environmental sustainable practices in Indian major ports.

In conclusion, the study has provided valuable insights into the efforts made by the ports to protect the environment while ensuring economic growth. The findings highlight the importance of continued collaboration between stakeholders and the need for ongoing research and innovation to address the challenges and seize the opportunities in the field of environmental sustainability. With the right strategies and collective efforts, Indian major ports can continue to lead the way in promoting sustainable development and setting an example for other ports around the world.

5.2 Suggestions

Implementing environmental sustainability practices in Indian major ports is imperative for fostering ecological balance, ensuring long-term viability, and meeting international standards. Based on the findings of this study, several suggestions emerge to enhance sustainability in port operations:

- Enhance the monitoring and assessment of environmental impacts associated with port activities through the use of advanced technologies and data analytics and implement real-time monitoring systems to track air and water quality, noise levels, and waste management practices. Regularly review and update monitoring protocols to ensure the effectiveness of sustainable practices.
- Encourage the adoption of clean and green technologies, such as electric vehicles and renewable energy systems, for port operations and Provide incentives and support for the implementation of energy-efficient equipment and machinery.
- Explore innovative solutions, such as alternative fuels and advanced waste treatment technologies, to further reduce the environmental footprint of port activities.
- Conduct regular forums and workshops to address concerns, gather feedback, and promote awareness about sustainable practices and Establish partnerships with research institutions and industry experts to enhance knowledge sharing and ensure continuous improvement in sustainable practices.
- Foster stronger collaboration and engagement with local communities, NGOs, and government agencies in decision-making processes related to environmental sustainability.
- Allocate resources for the development of sustainable infrastructure, such as wastewater treatment plants, waste management facilities, and renewable energy installations. Plan and design port facilities with a focus on minimizing environmental impacts, considering factors like noise pollution, habitat preservation, and energy efficiency.
- Ensure that infrastructure development projects follow rigorous environmental impact assessment processes and adhere to sustainable construction practices.
- Develop comprehensive training programs for port personnel and stakeholders to raise awareness about environmental sustainability and promote best practices and Provide training on waste management, energy conservation, pollution control, and biodiversity conservation.

Regularly organize awareness campaigns and workshops to educate the port community and surrounding areas about the importance of environmental sustainability.

- Encourage collaboration among Indian major ports to share best practices and lessons learned in environmental sustainability and establish a platform or network for ports to exchange information, experiences, and success stories. Facilitate the collaboration between ports and relevant government agencies, research institutions, and industry associations to promote innovation and knowledge sharing.
- Regularly review and evaluate the effectiveness of sustainable practices in Indian major ports and Set targets and benchmarks for sustainability performance and track progress towards achieving them. Conduct periodic audits and assessments to identify areas for improvement and implement corrective measures accordingly.
- Assess the impact of port infrastructure on local ecosystems and wildlife. Suggest ways to protect biodiversity. Consider creating green spaces within port premises, planting native trees, and establishing buffer zones to mitigate ecological disturbances.

5.3 Recommendation for Future Research

Here are some recommendations for future research related to Environmental Sustainable Practices in Indian major ports:

- Future research should focus on a holistic approach to port sustainability, considering the three dimensions: environment, economy, and society. This involves integrating environmental practices with economic viability and social well-being.
- Investigate how Indian ports align with the United Nations' SDGs (Sustainable Development Goals). Understanding how port actions contribute to achieving specific SDGs can guide policymakers and industry practitioners in making informed decisions.
- Explore the role of employees in environmental management practices within ports. Engaging port workers and understanding their perspectives can lead to more effective sustainability initiatives.
- Further research is needed on regulatory frameworks and environmental standards specific to Indian ports. Analyzing existing regulations and identifying gaps can inform policy modifications for better alignment with sustainability goals.
- Identify practical challenges faced by Indian ports in implementing sustainable practices. Understanding barriers can help develop targeted strategies for overcoming obstacles.
- Study the involvement of various stakeholders (including local communities, shipping companies, and government agencies) in port sustainability initiatives. Effective stakeholder engagement is crucial for successful implementation.

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