A Project on

GREEN PORT STRATEGIES FOR SUSTAINABLE GROWTH AND DEVELOPMENT OF PORTS IN INDIA

Submitted to the School of Maritime Management, Indian Maritime University in partial fulfilment for the requirements for the award of degree in

MBA- International Transportation and Logistics Management

Submitted
By

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DECLARATION

I, **SAI BHARATH (Reg. No. 2003305030)**, student of School of Maritime Management, Indian Maritime University –Chennai Campus, hereby declare that this project report titled **GREEN PORT STRATEGIES FOR SUSTAINABLE GROWTH AND DEVELOPMENT OF PORTS IN INDIA** submitted in partial fulfilment of the requirement for the degree of **Master of Business Administration in International Transportation and Logistics Management** is my original work carried under the guidance of my project guide. It has not formed the basis for the award of any Degree/Diploma of any University/Institution. The information submitted is true and original to the best of my knowledge.

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Certificate

SCHOOL OF MARITIME MANAGEMENT
INDIAN MARITIME UNIVERSITY, CHENNAI

This is to certify that the project report entitled **“GREEN PORT STRATEGIES FOR SUSTAINABLE GROWTH AND DEVELOPMENT OF PORTS IN INDIA”**, submitted to the School of Maritime Management, Indian Maritime University, Chennai Campus., in partial fulfillment for the award of the degree of Master of Business Administration in Port & Shipping Management/ International Transportation and Logistics Management, is a record of work carried out entirely by **SAI BHARATH**, Reg. No. **2003305030**.

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Place: Chennai

Date: 25th May 2022

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Executive Summary

Title of Dissertation: Green Port Strategies for Sustainable Growth and Development of Ports in India

Degree: Master of Business Administration in International Transportation and Logistics Management

Sustainable port and eco-port efforts appeared before green port initiatives. All of these approaches emphasize environmental concerns, and recent notions such as sustainable and green ports employ a "work with nature mindset." Many practical planning for eco-ports, sustainable ports, and green ports has been identified from worldwide, regional, and local organizations to guide these port developments, but only a few articles have concentrated on port sustainability planning. The Ministry of Transport of the People's Republic of China, for example, provided programs and strategies to plan a sustainable or green port, but perhaps the most greener or sustainable efforts in the United States were in the private sector; this is likely due to different systems of port governance in different areas; there was no consistent policy in place for port sustainability planning.

Nonetheless, sustainable port planning has maintained the objectives of sustainable development and endeavored to meet the demands of present and future generations through bottom-up problem/data-driven or top-down vision/goal-oriented planning procedures. Green port planning, in contrast to eco-port planning, which focuses on increasing environmental performance, is focused with natural conservation and ecological protection to some extent. The difference between these two approaches is whether the development goals are to meet human needs or to maintain the intrinsic worth of the natural ecosystem. Using sustainable education as an example, people would be taught to conserve the environment in order to serve human interests.

Maritime India Vision (MIV) 2030, produced by the Indian government, intends to boost India's ports, shipping, and waterways sectors through coordinated actions. The MIV 2030 has identified approximately 150 activities to carry forward the goal in each area. One of the MIV's focal points is the "Safe, Sustainable, and Green Maritime Sector."

India has committed to lowering its emission intensity per unit of GDP by 33-35 percent by 2030, compared to 2005 levels. India has also set a goal of obtaining 40% of its national energy from renewable sources by 2030. With 95 percent of total trade and 65 percent of trade value, the country's maritime industry is critical to overall commerce and prosperity. As a result, Indian ports must implement green measures that are consistent with the country's overall strategy.

In addition, Indian ports must comply with the International Maritime Organization's alignment to nine United Nations Sustainable Development Goals (SDGs), which include obligations on safe, efficient, and sustainable ports.

MIV 2030 has outlined the main interventions such as increasing renewable energy use, reducing air emissions, optimizing water use, working to improve solid waste management, implementing a zero-accident safety program, and establishing a centralized monitoring system to help India continue to lead the world in safe, sustainable, and green ports.

In order to ensure long-term development, the Ministry of Shipping has launched 'Project Green Ports,' which will assist in making India's major ports cleaner and greener. The two prongs of 'Project Green Ports' would be 'Green Ports Initiatives' relating to environmental challenges and 'Swachh Bharat Abhiyaan.'

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List of Abbreviations

GHG – Green House Gas

SDG – Sustainable Development Goal

WPCI – World Port Climate Initiative

NOx – Nitrogen Oxide

SOx – Sulphur Oxide

CO2 – Carbon Dioxide

LNG – Liquefied Natural Gas

PM – Particulate Matter

WHO – World Health Organization

IMO – International Maritime Organization

EU – European Union

UNO – United Nations Organization

ESPO – European Sea Port Organization

MoSPW – Ministry of Port, Shipping and Waterways

DWT – Dead Weight Tonnage

GRT – Gross Weight Tonnage

RTG – Rubber Tyred Gantry

EV – Electronic Vehicle

PIANC – Permanent International Association of Navigation Congresses

MARPOL – International Convention for the Prevention of Pollution from Ships

OECD – Organization for Economic Co-operation and Development

Chapter I

Introduction

1.1: Background and Significance of the study

In recent years, there has been a rise in interest in the environmental impact of port operations and expansion due to severe global concerns such as climate change and energy usage. The port industry is facing growing challenges as it is inspected more thoroughly in terms of environmental regulation compliance. Environmental concerns are especially prevalent in vessel and cargo handling operations, port expansion projects, and access to the hinterland. At the same time, enough capacity, high-quality services, and cost-effective solutions are essential.

As a result, it would be desirable to establish a green port plan that meets both economic and environmental goals while also contributing to the port's long-term growth and development. Ports in many industrialised nations are gradually implementing environmental rules in response to the growing challenges of global climate change and local air pollution, but some ports are cau tious to raise rates for their customers and risk losing traffic.

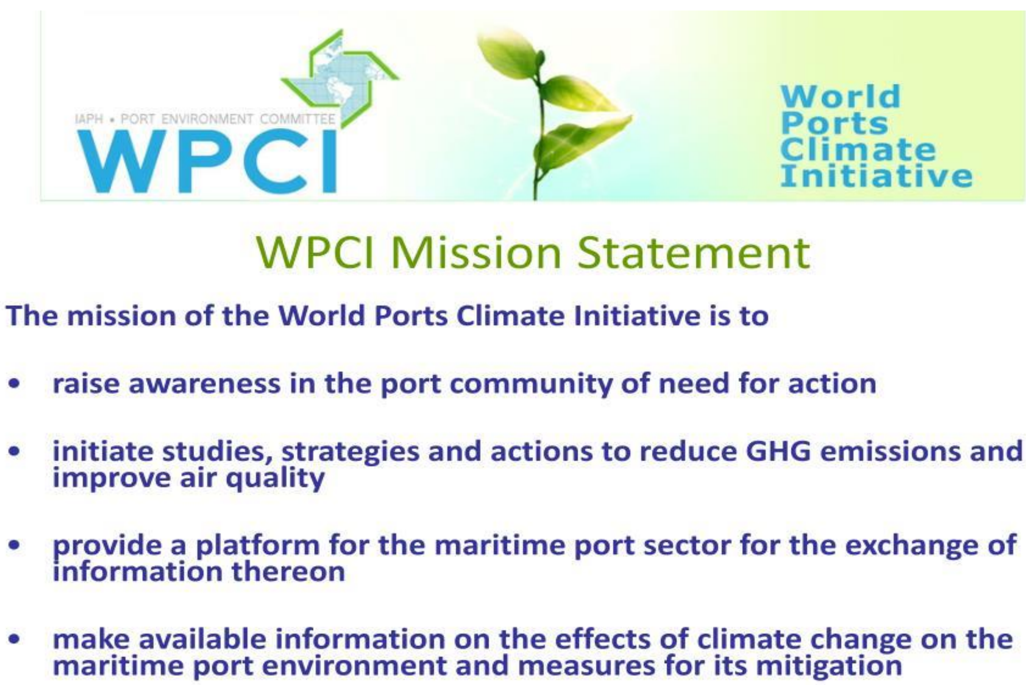
In a growing country like India, the conflict between port competitiveness and environmental preservation is far more acute. As a result, while green port methods aren't "one size fits all," they are a good starting point. The findings suggest that green port strategies adopted in the ports included investing in intermodal transportation connections and dry ports in the hinterland, decreasing trash, dust, and noise, and to a lesser extent, reducing emissions from port activities. This situation is similar to that of ports in developed countries, which prefer to act on items within their control, such as acts within the port and intermodal connections, but are least inclined to take actions that could raise carrier costs.

The ocean deservedly received more attention this year than ever before at important international events like COP26 and the United Nations Food Systems Summit, where its relevance in achieving the Sustainable Development Goals was underscored. The United Nations launched the Decade of Ocean Science for Sustainable Development in 2021, with the goal of discovering ocean-based solutions for all of the Sustainable Development Goals. The US and other major national governments, as well as private sector actors such as Amazon, have placed a renewed focus on ocean issues, raising awareness of a number of ocean-based mitigation strategies, ranging from investing in blue carbon to decarbonizing shipping.

1.2: Objective

Stakeholder involvement, green market development, cost-effective green policy, and sustainable port operations and development are all critical components of the framework. The Sustainable Development Goals were established by the United Nations in 2015, and they reflect a holistic and integrated approach to environmental preservation, community improvement, and even the global economy. As one of the most important centers of economic activity, the port sector might play a key role in ensuring that port business strategies, including port governance, meet global sustainability standards. The International Association of Ports and Harbors developed the World Ports Climate Initiative to support this SDG goal, as seen in the figure1.1.

Fig1.1: The World Ports Climate Initiative[1]



[1] International Association of Ports and Harbors

From the standpoint of green port management, the effectiveness of the green port concept is reliant on a number of factors. All of the plans aligned hall take into account all components, including economic and environmental aims, in terms of long-term growth. Aspects of green port sustainable development can be divided into three categories:

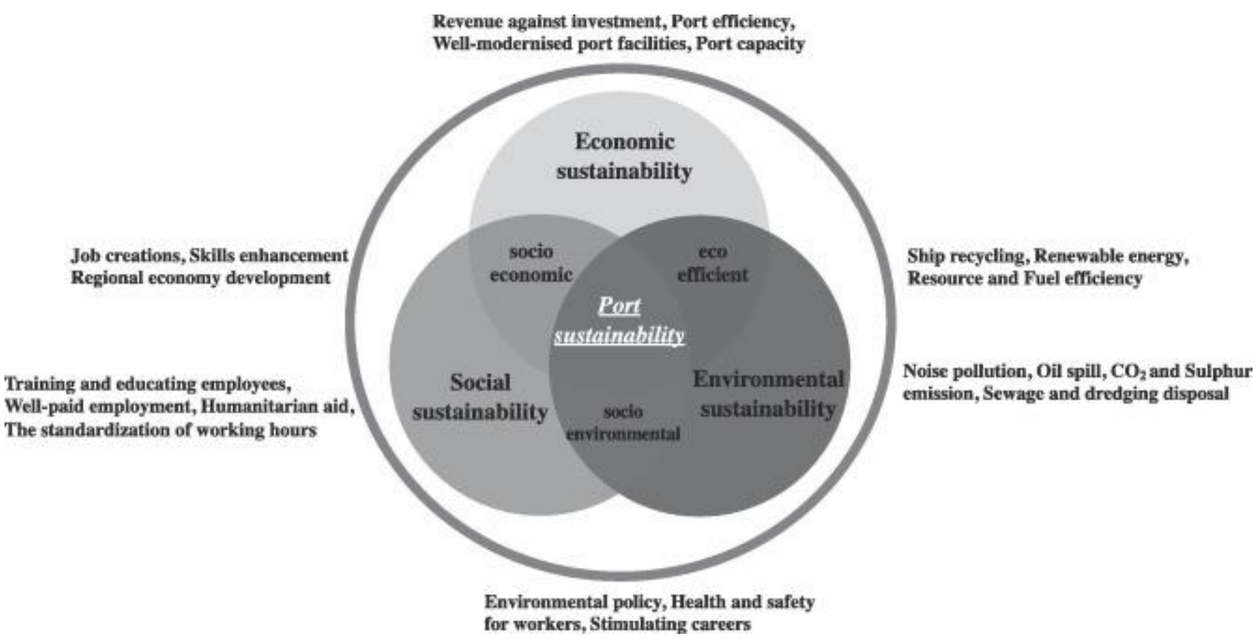
(i) economic

(ii)environmental

(iii)social.

These three groups will be the base for the analysis's structure.

Fig1.2: The concept of sustainable port strategy[2]



1.3: Methodology

This project is done by the most commonly practiced approaches used by researchers for their study. Collection of all the relevant data, analysis and statistics of the green port strategies for sustainable growth and development of ports in India was genuine and cent percent true. Methods

[2] Port sustainability and performance: A systematic literature review

followed to obtain the required output of this study were referring from external literature review such as journals, academics projects, publications etc. Statistical data were collected from the authorized websites, reviews and newspapers.

1.4: Structure

Structure of the project consists of 6 chapters. Chapter 1 includes the introduction, purpose, methodology and structure. Chapter 2 consists the literature review, which shows the background of the research which other researchers have studied to enhance the green port strategy. Chapter 3 deals with evaluation of green port with reference to its factors and performance. It deals with most important part of how to approach port planning for sustainability. 4^{th} chapter elaborates the Indian Ports Association's plan towards making the ports greener, sustainable and safer with implementation process, roles, responsibilities and consequences. 5^{th} chapter provides the indicatives in India, interventions in reducing carbon, recycle, resource management and eco-berthing done in India. Last chapter concludes the project with its current obligations in Indian ports, suggestions to improve the ports eco-friendly, renewable energy to power the ports etc. and summary of the project and ending with bibliography.

Chapter II

Literature Review

The literature to date has yet to fulfill the much desired industry demand. The study aims to fill the gap by formulating a framework in green and sustainable port strategy. The research objective is firstly achieved by a comprehensive literature review and conceptual development.

2.1: Factors Affecting Environment at Port[3]

The amount of global trade, or seaborne trade, is predicted to grow each year, implying the movement through port would grow as well. Taking air pollution as an instance, large emissions of particulate matter, diesel exhaust, and nitrogen oxides can be found near ports, resulting in respiratory disease, asthma, premature mortality, cardiovascular disease, and lung cancer in local areas (Bailey & Solomon, 2004). According to the OECD (2017), pollution sources in the context of a green port could be categorized into three categories:

(i) port's activity,
(ii) ship's emissions, and
(iii) future ports

The actions of ports have had a significant negative impact on the environment. Pollution from ships or other industrial activity in port locations could affect the air, water, soil, waste, and noise levels. Various diesel-powered machinery, including as straddle carriers, terminal tractors, and reach lifters, were employed in port operations. Not only did these diesel-powered engines spew numerous pollutants, but they also produced noise, which is another sort of pollution.

Noise pollution from numerous diesel engines in the port may cause hypertension, cardiovascular illness, and mental stress, particularly in workers who are exposed to the environment for extended periods of time. Ports that handled a huge volume of items such as wood, fertilizer and aggregates, on the other hand, contributes to air pollution as a result of dust drifting due to dry and windy

[3] Pollution prevention at ports: Clearing the air

circumstances. This form of pollution can have a negative impact on workers' health, as well as the health of nearby communities and residents.

Other environmental concerns related to the port's operations include ballast water control in port water. Ballast water, as we all know, is critical for a ship's safe operation, as it offers stability and maneuverability throughout voyages, loading and unloading activities. The treatment of this ballast water, however, may have an impact on the coastal ecology by importing exotic species or pathogens carried by ships. Furthermore, environmental difficulties have arisen as a result of the port development effort, which includes dredging and reclaiming, putting wetlands, coral reefs, and marine ecosystems at risk.

The environment, air quality, and human health have all suffered as a result of increased shipping activity in port locations. Pollutant receptors created by ships are especially visible in port locations. Approximately 80percent of the global fleet is operating in port facilities (55percent of the time) or close to the shore (25 percent of the time). Ships spend just about 20% of their time away from land. It is expected that 70% of ship emissions occur within 400 kilometers of land. While berthing or moving, ship emissions may pose a hazard to air quality in coastal regions as they travel down the coast. Air pollution from vessels can be very significant in port regions because to the maneuvering, bunkering, and hoteling stages. When ships are berthed, the bulk of them use auxiliary diesel engines to deliver their services. Port NOx and SO2 emission amount for 5-6 percent of total ship emissions across all phases of navigation. The main cause of air pollution is particulate matter produced by ship emissions. Furthermore, the huge emissions intensities generated by vessels were not only a burden on the regional and global environment, but also had an impact on human health. Air pollution has been linked to an increased risk of cancer across over 30 human epidemiological data, and children who live near large traffic hubs are more likely to have decreased lung capacity, wheezing, and bronchitis. The International Association of Cancer Research has classified diesel pollutants as "genotoxic carcinogenic" in general.

A seaport is a transport node that can handle many kinds of transport. Typically, road transport dominates all hinterland transportation in most ports. This results in heavy truck traffic in port cities. Trucks emit the most significant quantity of air pollution emission components in road freight transport, according to a report by the Organization for Economic Cooperation and Development. The volume of cargo transported by road from seaport to hinterland is tremendously increased, resulting in increasing congestion and pollution from transportation.

Apart from ships and some cargo handling machinery, land transportation such as lorries or trains also produce noise that may damage surrounding residential areas. This situation becomes even worse for ports that are open 24 hours a day. Ports and other stakeholders must develop innovative solutions, including methods for assessing the hinterland transportation system, in order to preserve sustainable transportation. At the same time, port communities are increasingly implementing a strategy or policy to reduce the negative consequences of seaport transportation.

2.2: The conception of a Green and Sustainable Port[4]

This article outlines a methodical strategy for putting green port concept into action that goes beyond investing in specific technology. It goes without saying that implementing the green idea is a continual process that must establish circumstances for a long-term change in port operations. Knowledge of energy use and environmental implications is one of the key pre - conditions for successful greening and overall power efficiency improvement, according to the research presented. The proper choice of the initial projects being implemented proven to be critical in bringing the green port concept to life, as early attainment of clear results is required to enhance employee and management trust.

A critical issue is the availability of adequate data and expertise that reveals where the capital profitability threshold is. The engagement of multi-disciplinary teams such as energy managers, environmental managers, operators, and maintenance employees is essential owing to the difficulty of port operations. On a practical level, it has been confirmed that implementing the green port concept, which is backed up by an intelligent sustainability and renewable management system, allows for a clear definition of roles and empowers workers who operate machineries and work on the factory floor to achieve long-term performance improvements. Information regarding previous performance sparked healthy competition among RTG crane operators. In ports, an

[4] Green port marketing for sustainable growth and development

effective and efficient environmental and energy management system aids decision makers in becoming more aware of energy efficiency and environmental performance and bridges the gap between theory and practice.

Today's ports are responsible for much more than just quayside cargo management. Their competitors' sources of competition and influence extend across the sea as well as deep into the interior. Both management and operational processes are intertwined with stakeholders on a variety of scales and in a variety of realms, from local to global, business to government. The port's position in the transportation chain has the capacity to influence the environmental and social performance of global transportation systems. While many ports opt to comply with existing environmental standards in their city, region, or country, they have in many cases used their capacity to address social and environmental externalities.

In recent years, researchers have evaluated and quantified pollutants from the maritime domain, which could serve as a baseline for future projections. When the primary focus of this study is on port emissions, attention to emissions in the marine sector has largely centred on vessel output while at sea. nitrogen oxides (NOx), sulphur oxides (SOx) and particulate matter (PM) are the main greenhouse gas emissions that contribute to global climate change plus local air pollution. In 2007, shipping accounts for 2.8 percent of worldwide GHG emissions, more than double that of air transport. Because of their negative impact on human health, local pollution is a more significant concern in coastal communities. According to data from the World Health Organization, nearly all of the world's population (99%) breathes air that surpasses WHO guideline limitations and contains significant amounts of contaminants. Shipping should make a big contribution to the Green Port. Shipping contributes for 9% of world sulphur oxide (SOx) pollution and 18% -30% of world nitrogen oxide (NOx) pollution, which cause substantial damage to the both health and environment, according to the World Health Organization (2021).

2.3: Shipping Emissions[5]

It is well known that ship exhaust emissions have a significant impact on pollutant and global warming agent mass inputs and diminish air quality around port areas. Higher emissions were estimated at few ports due to marine traffic intensity. Estimated SO_2 concentrations were higher than the observed concentrations. Because sulphur content of marine fuel may vary and recent amendments in the related regulations limit its amount to lower values. Advancement of on-board SO_2 emission control on ships can also have a reducing effect on emitted SO_2 emissions.

Air pollutants, noise, water pollution and oil waste are all environmental repercussions of shipping traffic. Shipping activities are responsible for more than 18% of an air pollutant. Concerns about the influence of ships on the environment are developing in tandem with the growth of marine traffic. As we all know, CO2 emissions from shipping contribute considerably to global warming, while NOx and SOx emissions do not. PM and Volatile Organic Compounds have the greatest impact on human health in port cities. According to IMO 2020, shipping activities release around I billion tonnes of CO2. Based on prospective energy development and economic growth shipping emission may increase by 50 to 250 percent. As a result, the 72nd International Maritime Organization meeting in 2018 established tighter requirements for lowering yearly pollutants by at least 50% by 2050.

Various nations and towns across the world have implemented incentive schemes in the port area to encourage ships to use better marine fuels or to reduce air pollution while arriving at ports. For instance, the Environmental Ship Index, which was created in 2010, is one of the incentive schemes implemented by ports to promote improved air quality as a result of shipping activities, especially in the port region. Major ports including Le Havre, Hamburg, Bremen, Antwerp, Amsterdam, and Rotterdam have already successfully enlisted in this scheme. Together with the IMO's ongoing emission criteria, the ESI offers a reduction in port fees or tonnage costs to vessels with below baseline SOx, NOx, and/or CO2 emissions. Other initiatives to reduce NOx emissions by

[5] https://www.transportenvironment.org/challenges/ships/greenhouse-gases/

ships include the Ship Energy Efficiency Management Plan and the Energy Efficiency Design Index.

Other pollution reduction techniques involve slow steaming while approaching or in ports. A 20% drop in speed results in a 40% reduction in fuel usage and a 7% reduction in CO2. This alternative, however, is only appealing if indeed the bunker rates for each tonne are quite high, according to. Furthermore, by providing onshore power, pollutants from ships in ports can be reduced. Emissions from berthing ship engines contribute significantly to emissions in ports. If shore power is used in all European ports, an approximate 2,94 billion euros in healthcare expenditure might be avoided in 2020, as well as an 800.000 tonne decrease in carbon emissions.

2.4. Environmental Concerns in Port[6]

Pollution from port operations contributes less to overall emissions that can be addressed with particular ways, although only a few ports currently analyze their emissions. Adopting ways for managing power requirements and producing renewable energy locally is one of the approaches that ports might use. Wind turbines, solar panels, and thermal plants are examples of renewable energy. Ports, on the other hand, should examine additional measures such as trash management and recycling facilities, ballast water management and sewage, spills as well as reducing the amount of vibration, noise and dust produced by the ports. Many initiatives are being implemented to reduce pollution caused by port operations, such as the use of LNG-powered trucks. Some ports, such as the Port of Rotterdam, have pushed port-based businesses to track their carbon footprints and continue to promote the use of sustainable energy to reduce CO2 emissions.

When ports try and implement green regulations at their ports, they face numerous problems and issues. The problems could stem from the cost and complexity, a lack of infrastructure, prohibitively expensive installation costs and queries related to governance and various

[6] https://www.transportenvironment.org/challenges/ships/greenhouse-gases/

institutional issues. An important part of governance is the effective identification and introduction of ecologically friendly operations.

2.5. Things in Practice[7]

The International Convention for the Prevention of Pollution from Ships, developed by the International Maritime Organization, addresses environmental degradation in the maritime industry. These treaties, which have been amended over time, address issues such as oil spills, emissions and ballast water. The International Maritime Organization has set Emission Control Areas having 0.1 percent Sulphur limitations since 2008, and a global Sulphur restriction of 0.5 percent will be in effect from 2020, down from the existing level of 3.5 percent. New vessel limitations, the Energy Efficiency Design Index and the Ship Energy Efficiency Management Plan are all used to reduce NOx emissions. The IMO has not yet imposed a global CO2 limit. These imposed norms have spawned new study areas in ship emission control, such as confirming a new vessel standard that might make shipping more ecologically friendly or determining alternative routes. Auxiliary engine upgrades, more efficient ship hulls, and propulsion upgrades are all technological issues. All of these factors point to an increasing trend toward ships that are more environmentally friendly. Increased environmental rules, on the other hand, may harm ship owners' interests due to higher refit costs.

Some substantial ports in the United States are taking unilateral action. For example, the Port of Long Beach initiated a voluntary programme called the "Green flag incentive," which offered port dues discounts to incoming ships that reduced their speed in the port facilities, which is one of the primary goals available to ports for reduction of emissions from vessels. In addition, beginning January 1, 2017, the At-berth Rules require all vessels calling at California ports to use shore-based electrical power in order to minimize pollution.

The European Union's port policy encourages seaports to charge environmental fees. The Port of Rotterdam is one of 30 major European ports that have implemented green levies for infrastructure use. It created Green Award reductions for ships based on their environmental performances to encourage them to minimize pollutant emissions; ships holding a legitimate Green Award

[7] Sustainable port infrastructure, practical implementation of the green port concept

certificate might receive a 10% to 20% discount on port fees. In addition, the EU Commission can grant financial support for fixed, mobile, or offshore port infrastructure that allows a port to supply boats with energy sources such as hydrogen, electricity or liquefied natural gas to enable investments in green port infrastructure. The European Fund for Strategic Investments and the European Investment Bank have established the V750 million EFSI Green Shipping Guarantee Program, which is accessible to both retrofitting existing ships and building new vessels with a green innovation component. Various funding programmes and EU research are also available to assist member states in implementing alternative fuel infrastructure that contributes to transportation decarbonization and improves the maritime sector's environmental performance.

2.6: Future Ports[8]

Ports, like airports and roads, are important facilities that enable the global economy to function. The worldwide shipping industry transports around 90% of global trade. Ports have played a key role in the global economy and trade development, resulting in increased demand for logistical services. As the world enters the Fourth Industrial Revolution, it is predicted to increase the global market for Smart Ports, fueled mostly by the desire of ports to lower shipping time and cost through digital transformation.

In view of the Fourth Industrial Revolution, basic infrastructures such as ports will be digitally transformed to meet rising market needs and achieve greater efficiency. The upcoming 4IR technologies have started opening a slew of new port-related application opportunities. Processes that are automated and interconnected via the Internet of Things would be suitable for Smart Ports. To increase performance and economic competitiveness, the ports' operations can be automated using emerging technologies such as Internet of Things, block chain solutions, Big Data, Artificial Intelligence and other smart technology methods. These sophisticated technologies will also help ports to be more environmentally sustainable.

[8] Ports of The Future – Smart and Green Ports – 27 Advisory

2.6.1: Key Improvement Area

A: Operational efficiency

Containers, transit, and cruise ships are all rising in size and volume, posing everyday difficulties to ports. Port facility management and inventory management can be considerably improved with emerging technologies such as the Internet of Things. Furthermore, the Internet of Things could be used in load automation, dispatching, and goods transportation.

The use of AI in Smart Ports would concentrate on automated screening processes and security checks, which might standardize and shorten the time it takes to complete jobs. Furthermore, AI technologies will aid in improving the safety and dependability of port duties while also reducing the need on human failure.

Aquatic drones are yet another innovation that can be used. These underwater drones can influence piers or ships and detect any flaws that may arise in ports. Furthermore, aquatic drones can perform work that is hazardous to people in regarding safety. It is also conceivable to computerize techniques that will benefit operators by alerting them to any possible hijacking or loss of privacy when a ship abruptly slows or changes direction.

Other technologies, like as cameras, sensors and drones, could improve efficiency by automatically gathering and analyzing data such as weather, traffic and pollutant data for port owners and customers, allowing Big Data Analytics to optimize operation planning.

B: Business Economics

Ports are projected to really be able to effectively simplify and cut costs from an economic standpoint. Determining the flow of traffic of ships can be challenging manually, but by automating the process, faster loading and unloading speeds for ships can be achieved, allowing more vessels and cargo to be processed in less time. Aside from these possible advantages, automation reduces overhead and costs, allowing smart ports to become less financially reliant on governing bodies and allowing for more private investment and upgrades.

C: Environmental sustainability

Ports have seen severe amounts of environmental pollution in recent years. By better managing energy use and waste, automation and smart technology may be able to tackle this problem. Hamburg, located far inland in Germany, is one city which not only maintains a smart port and it has also been able to efficiently employ technology. Because of its proximity to the water, Hamburg was able to implement a system of sensors, cameras, and smart lights on highways to help monitor and control traffic, thereby reducing emissions.

2.6.2: Ports of The Future Will Be Smarter and Greener

Green ports and smart ports are inextricably linked. Ports should strive to become Green Ports and implement intelligent port development as a secondary goal. Low power consumption, low emissions, and low pollution will result from transforming a port into a green and smart one. It is vital to have help in terms of awareness and technological innovation in order to attain smart and green ports. A smart port, in addition to its goals of better effectiveness and efficiency, as well as a larger contribution to environmental sustainability, makes full use of space, generates higher profits, conserves natural resources, and benefits from technology available to the logistics community.

As a result, there is little question that the use of Smart Technology in ports will not only rise in the future, but will also become a requirement, resulting in the ports of the future. However, both brownfield redevelopment and greenfield port expansion will necessitate significant capital commitment from operators and government agencies. As a result, careful planning is required to achieve a successful transformation. Below are a few pertinent areas to be considered:

- Complementary features and cutting-edge digital infrastructure in the masterplan. Other economic activity such as manufacturing, refineries, and inland logistics are closely linked to port growth. Land use as well as digital infrastructure design should incorporate optimal logistical flow and productivity improvement to enhance the value and productivity of land assets.

- An effective funding and collaboration strategy. Depending on the extent and location, port developments can cost billions of dollars. There are other funding sources available, but the administration will need to establish a concession framework to ensure that the government budget is used more efficiently.

- Aspects of cost over time. The components, particularly the digital infrastructure and facilities, will be employed for an extended length of time, possibly up to 20 years. If not effectively managed, the expense of maintaining and repairing infrastructures could be enormous. As a result, it's critical to use a life-cycle accounting approach to evaluate development possibilities in order to narrow down the best development with the best cost profile.

Chapter III

Evaluation of green port

The backbone of the expanding global economy and international trading system is maritime transit. Nonetheless, greenhouse gases and some other pollutants from ships and other marine commerce activities have had substantial environmental consequences, particularly in coastal areas. Local pollution and climate change exacerbated by GHG emissions from the port region are now attracting increasing attention as the functions performed by ports have expanded dramatically from only the handling of vessels and cargo to the pursuit of a broad variety of interests. Yet, both in maritime trade or within the port, balancing economic operations and environmental concerns remains tough.

The United Nations established sustainable development in 1992, but the concept of "green ports" has only recently gained traction as it is understood that seaports must reduce emissions from current and future operations in the port region as well as the broader logistical area. At the same moment, ports must maintain an emphasis on port growth while also focusing on reducing emissions and more environmentally friendly methods. As a result, a green port strategy would achieve both environmental and economic goals, resulting in long-term development. As a result, the port's duty is to combine port strategy, corporate social responsibility and the requirement to comply with federal, state, and municipal environmental regulations. Some of Europe's and America's major hub ports have already implemented its own green port programmes. However, because each port has different operational conditions, pollutant targets, terminal type, and configuration, there is no "one size fits all" strategy for all ports, and every measure must be evaluated on an individual basis. Furthermore, there are few examples in the academic literature that focus on developing countries, where economic expansion and environmental conservation are increasingly at odds.

3.1. Influencing Factors

Environmental studies on port-related concerns are quite varied. The minimizing of environmental effects has become a key problem for port operations in recent years. Ports have been working to become "greener" by implementing new technology and updating infrastructure while reducing energy consumption. The port is viewed as a system with various components, each of which contributes to the port's environmental footprint. Maritime activities, on-land transportation and port operations can all be split into three groups. As transportation activities has expanded, air pollution, contaminants, noise pollution, and traffic jams have all increased. Transportation infrastructure, such as highways, ports, trains, and airports, has the potential to impact the environment. As a consequence, the green concept is gaining popularity as a way to create and operate port businesses in order to reduce pollution.

According to a research conducted by the Organization for Economic Cooperation and Development, well-functioning ports can help promote economic development in the surrounding regions and wider hinterland; yet, port activities can have major negative environmental consequences. Sea transport operations have an impact on the environment both within ports and in the immediate area of ports. Noise from vessel engines and equipment used for loading and unloading, particle exhausts from the ship's main and auxiliary engines, and dust from the handling of grain, sand, and coal are examples of these impacts. Additional environmental issues arise as a result of road and rail traffic from and to the port region. The environmental impact of ports can be split into three areas in general.:

(1) issues resulting from port activity.

(2) ships calling at the terminal cause complications at sea.

(3) emissions from the port's hinterland's multimodal transportation networks.

Because of the diversity of these consequences, a wide range of policy instruments must be used to manage environmental impacts and the "ideal" mix of instruments is likely to differ significantly from port to port.

According to the American Association of Port Authorities' publications, seaports are frequently located in or near residential settlements and/or environmentally sensitive estuaries, as Bailey and Solomon noted out., the following environmental concerns were commonly mentioned:

(1) Smog and particle pollution are examples of air pollution caused by port operations.

(2) Wetland loss or degradation

(3) fisheries depletion and endangered species

(4) releases of storm water and wastewater

(5) severe traffic congestion

(6) noise and light pollution

(7) loss of cultural resources

(8) leaky storage tanks contaminate the earth and water

(9) Chemical storing or fumigation activities release air.

(10) creation of hazardous waste and solid

(11) soil runoff, erosion, and other issues.

Fig.3.1. Pollution caused by port facilities[9]

They concluded that lowering pollution for ports while moving to a sustainable business model that supports a local region without jeopardizing the health and purity of local populations and ecosystems would demand a range of strategies.

[9] UNCTAD

Significant environmental aspects in sea ports are

(1) emissions in air (includes gases, energy and solid particles; dust is a significant contribution)

(2) discharge into water (e.g., accidental releases during loading/unloading operations and waste waters)

(3) emissions into the soil caused primarily by industrial activities

(4) activities that influence the seafloor and discharges to marine sediments (such as dredging)

(5) noise (and its potential impact on people and animals)

(6) creation of garbage and dredging disposal

(7) habitat destruction/degradation on land

(8) alterations to marine habitats

(9) odors

(10) resource consumption

(11) Development of ports (land and marine occupation)

That's from a study, 21 port activities in industrial ports can produce a total of 63 types of potential environmental consequences, necessitating the application and strengthening of control over these activities in order to restrict the scope of the problem. Environmental repercussions can be classified as water pollution, air pollution, noise pollution, odor pollution, soil pollution, trash creation (urban waste and hazardous waste), resource use, and other environmental effects.

In the case of Poland, the top 10 environmental concerns of three Polish ports in 2012 are as follows:

(1) ship waste (sewage)

(2) noise

(3) dust

(4) dredging (disposal)

(5) port development (land)

(6) conservation areas

(7) ballast water

(8) ship exhaust emission

(9) energy consumption

(10) relationship with local community.

Given that most studies on maritime pollution control have focused on technical aspect and operating issues for deep sea transportation, another study shows that pollution spillover and inter-port contest can lead to distorted pollution taxes and emission limitations in the lack of inter-port coordination. As a result, despite the possibility of competition among ports in a region, they propose for regional ports to integrate their pollution control efforts. Data Envelopment Analysis is used to investigate the undesired outputs that ports produce, such as pollutants, using data from Korean ports. It is investigated the environmental efficiency of Korean ports in order to assess the country's potential emission reduction. When examining both economic and environmental performance, the study finds that Korean ports are economically inefficient yet environmentally efficient.

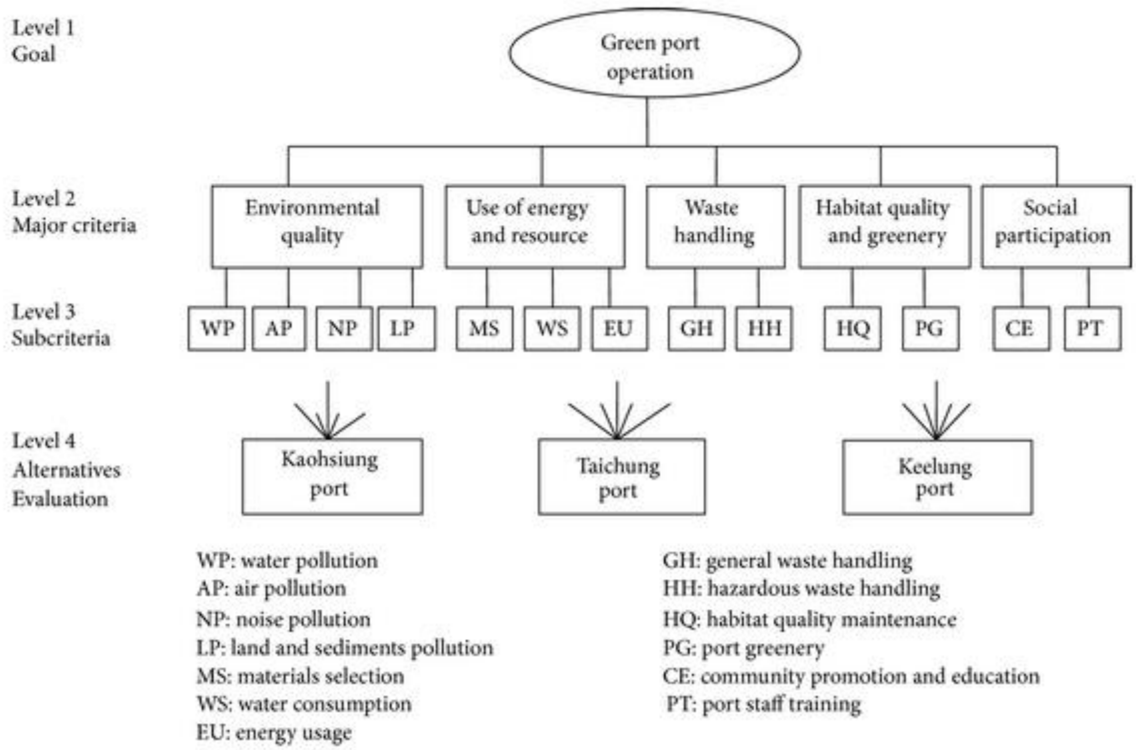
The previously stated studies show a wide range of study paths on many elements of green port concerns. Many academics are studying the different types of pollution, and some of the research also bring out the origins of pollution. When faced with diverse kinds of pollution, most studies recommend some control measures, and many port authorities throughout the world have set goals and implemented actions to reduce environmental effects within their ports. However, few studies look into how a port might priorities the importance of green port elements while selecting environmental management measures. Studies have identified 12 categories of green port measures after examining scholarly papers and numerous port administrations' green port and sustainable strategy documents. Environmental quality, energy and resource consumption, habitat quality, greenery and waste handling, as well as social engagement, can all be divided into five dimensions.

Many detailed activities may be taken to accomplish the target of constructing up and operating a green port (including air pollution, noise pollution, water pollution, land and sediment pollution, water consumption, materials selection, energy usage, general waste handling, habitat quality, hazardous waste handling and greenery, education and community promotion as well as port staff training). It would undoubtedly be difficult to expect every port authority would take all of the necessary steps to obtain green port status. The implementation of green port actions should be a gradual procedure. As a result, the necessity and priority of the green port initiatives for gaining "greener" status must be investigated further. The methodology of the suggested Analytic Hierarchy Process, which was refined by integrating a fuzzy idea and dubbed Fuzzy AHP, can thus be used to determine the relative relevance of green port characteristics. In practice, if a port cannot adopt all of the green measures at once, the port authorities may choose some of the most important ones to adopt first, and then progressively complete green port operation.

3.2. Performance

The first stage in the AHP model is to create a hierarchy structure that comprises a goal, several forms of influence criteria, sub factors and decision alternatives in order to determine the optimal choice. Before they may be compared, sub criteria inside a criterion should be homogeneous. Criteria in same hierarchy should be independent of one another. An AHP model for green port is constructed and displayed in Figure 3 based on the green port works of literature evaluated for this investigation. It consists of five main criteria dimensions and 13 sub criteria that will be used to determine whether a port meets the criteria for green operation.

Fig3.2. An AHP model for green port assessment[10]



Based on a survey of numerous port authorities' green port initiatives and studies, the green port operation with five dimensions have been classified. In relation to the 13 sub criteria, gives additional specific information on what activities the port authorities must do to improve their greener status. These 13 variables are extremely important in running a green port. Under the 5-point scale, the mean value of significance is all more than 3.5. As a result, the study's green port hierarchy structure is found adequate.

3.3. Importance

Evaluation of Green Port Factors and Performance with the FAHP Model has made significant contributions:

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[10] Evaluation of green port factors and performance: a fuzzy AHP analysis

(a) examination of prior academic studies and various port administrations' practical operations to discover the elements of green ports

(b) to develop an AHP model for highlighting the importance of green port elements and providing assistance to the port industry on how to build and operate a greener port

(c) to present a fuzzy-AHP technique for assessing the performance of green ports.

Green growth is proposed as a way to pursue growth in the economy while preventing environmental degradation, according to the Organization for Economic Cooperation and Development report. Growing concern about environmental depletion of resources of past economic growth patterns, as well as greater awareness of a potential future climate crisis, have made it very clear that environment and economy can no longer be called in isolation.

(i) After evaluating a number of studies on port operations in connection to protection of the environment and green issues, it appears that the majority of the studies are primarily concerned with pollution sources. Furthermore, many port authorities suggest green rules and force users (such as vessel calling) to observe their pollution-reduction methods. However, it appears that no comprehensive model for measuring a port's green performance has been developed. The present study proposed a FAHP model for assessing the green port operation based on existing literature. (Figure 3.2).

(ii) The importance of the five primary criterion and thirteen sub criteria has been determined. The findings could be used by port decision-makers to prioritize their efforts and actions in order to create a "greener" port operation.

(iii) The FAHP model for green ports can also be used to assess the port's green operation performance. This research offers a more straightforward method of obtaining results. The more practical course of action is to prioritize the most relevant factors for implementation. The AHP or FAHP technique is an effective way to assist decision-makers in taking suitable actions.

3.4: Approaches to Port Planning for Sustainability

3.4.1: Sustainable port planning

• The green ports using FAHP could also be used to evaluate the performance of the port's green operations. This study presents a more straightforward approach to achieving findings. Prioritizing the most important factors for implementation is a more practical approach. The AHP or FAHP method is a useful tool for assisting decision-makers in adopting appropriate actions.

• In 2013, the PIANC provided guidance to port authorities on how to build sustainable ports, including defining sustainable ports to fulfil the needs of current and future generations, analyzing port authority roles, identifying environmental sustainability problems in ports and related logistic chains, and formulating strategies.

• The International Association of Ports and Harbors established a World Ports Sustainability Program in 2018 to help implement the United Nations' Sustainable Development Goals. This programme will spread awareness of the missions and goals, as well as establish new projects and initiatives.

3.4.2: Eco-port planning

• The ESPO created an eco-port certification scheme that comprises port environmental review, self-diagnosis and certification. The ESPO produced the Green Guide in 2012 to help frame the approach to port environmental and sustainable management, which includes creating a goal to enhance environmental performance and efficiency.

• The Port of Osaka provided an eco-port planning concept in 2011, which included environmental protection and mitigating environmental impacts caused by port expansion.

3.4.3: Green port planning:

• In 2000, the Urban Harbors Institute at the University of Massachusetts, Boston, proposed an approach for environmental management of America's green ports, which included avoiding, preventing, minimizing, mitigating, or remediating environmental impacts associated with port development and operations.

• In 2005, the Port of Long Beach established policies for a green port by adopting particular environmental principles, like setting goals, establishing precise metrics to monitor progress toward those goals, implementing environmental programmes, and proposing specific incentives and legislation.

• In 2006, the Port of Sydney released green port development guidelines, which outline ideas and practices that are both environmentally beneficial and economically viable.

• In order to construct a green port in 2008, the San Diego Unified Port District established goals and objectives in the areas of improving water quality, conserving energy, lowering air emissions and waste, establishing a sustainable building, and increasing employee and public sustainability knowledge.

• In 2010, Singapore's Maritime and Port Authority pushed ocean-going vessels to use clean fuels and reduce pollutants such as sulphur oxides and nitrogen oxides in order to achieve a green port.

• In 2011, the People's Republic of China's Ministry of Transport issued opinions to support the sustainable development of coastal ports, proposing green measures such as energy conservation, emission reduction, and environmental protection based on the problem's identification. Based on the government's development goals, another opinion proposed green solutions for a green port by the Ministry of Transport, which include resource conservation, energy efficiency improvement, emissions control, and environmental protection. In 2018, the Ministry of Transport released a draught action plan to promote green port construction (2018–2022), which proposed green development strategies such as low carbon and circular, pollution prevention, resource conservation, and environmental protection based on government development goals.

• In 2014, the Jiangsu Province Department of Transportation released the Three-Year Action Plan for the Construction of Green Ports in Jiangsu Province (2018–2020), which proposed green actions such as energy conservation, emission reduction, pollution prevention, and shoreline resource protection to implement national strategies.

• The Department of Transportation of Guangdong Province, China, issued the Green Port Action Plan (2014–2020) in 2014, and the Port of Shanghai issued the Shanghai Green Port Three-Year Action Plan in 2015, both of which proposed green actions such as energy conservation, emission reduction, and pollution prevention in order to implement national strategies.

• In 2019, the Chinese Port of Xiamen released its 13th Five-Year Plan for establishing a green port, which proposed green strategies such as resource conservation, environmental responsibility, and social responsibilities for environmental protection and ecology in the port through a status assessment.

We may agree that existing port sustainability initiatives are either problem/data driven or vision/goal driven. Bottom-up approaches are problem- or data-driven techniques that primarily rely on assessing the impact of port activities. International organizations and associations, port authorities and governments have all adopted vision or goal-oriented techniques in planning. Most top-down methods have suggested ideas or activities for establishing eco-ports, sustainable ports, and green ports. Both approaches draw attention to environmental concerns.

Chapter IV

India on Green and Sustainable port

"Climate change" has arisen as an existential threat to the globe increasing temperatures, Green House Gas emissions, and disruption of the natural ecology. As a result, governments all around the world ratified an international agreement to combat climate change at the United Nations Framework Convention on Climate Change, Conference of the Parties 21 in 2015. India has been a major player in climate change negotiations. Countries publicly revealed their voluntary climate change initiatives, known as "Intended Nationally Determined Contributions," under the accord. India is emerging as a climate change leader, announcing its lofty INDC plans. Some of these targets are as follows:

1. By 2030, cut emission level per unit of GDP by 33-35 percent compared to 2005 levels.

2. Additional tree cover will create a carbon sink of 2.5-3.0 billion tonnes of carbon dioxide.

3. By 2030, non-fossil fuel-based power generation capacity will account for 40% of total power generation capacity.

Ports are a crucial infrastructure sector that handles 95 percent of all international trade (by volume). Ports also pollute the air and water, as well as emit greenhouse gases. Targets have also been set for the shipping industry globally.

These are as follows:

• By 2030, the International Maritime Organization (IMO) has set a target of a 40% reduction in CO_2 emissions from the shipping industry.

• 'At the World Ports Climate Action Program, CEOs of 11 major global ports pledged a set of five agreements to minimize carbon emissions in respective ports.'

The Indian ports sector has been working to reduce pollution and emissions in accordance with the INDC and global shipping targets. The MIV 2030 has laid the groundwork for coordinated action. The MIV 2030 has set several goals for ports to strive for in order to ensure sustainable infrastructure and services.

These are as follows:

• By 2030, increase the amount of renewable energy in major ports to over 60%.

• Air quality improvement

• Port equipment electrification

• LNG bunkering

• Water and solid waste management

• Safety program

India has lofty climate targets that will necessitate measures across important industrial and infrastructural sectors, and the port sector's action against climate change will be the "Green Ports Policy."

4.1: Need of Green Port

The Green Ports Policy (GPP) focuses on building on the MIV 2030 goals by providing information on various implementation models and incentive frameworks. The goal of this strategy is to promote stakeholders (port operators and port authorities) to develop steps that will lessen the sector's influence on climate change.

These regulations were created to address the Indian Ports' long-term sustainability and environmental issues. This policy is an integral part of the Indian government's overall sustainability strategy. For port authorities and port authorities, the Green Ports Policy statement captures the target areas, measure results, implementation plan, cost recovery system, capacity building, and monitoring mechanism. The proposed objective outcomes will assist India in meeting both the INDC and the IMO 2030 targets. The goals set out in this policy paper are consistent with the MIV 2030 document, which also includes a list of goals that ports should strive for in order to ensure sustainable infrastructure and services. This policy statement will enable the ports to meet the MIV 2030 document's environmental goal. The parts that follow go over many facets of the green port policy.

4.2: Roles and Responsibilities

The stakeholders' roles and responsibilities in the shortlisting, reviewing, approving, implementing, and lastly measuring the outcomes of any initiatives have indeed been outlined.

PPP Port Operator (PO)-

• To accomplish the specified objectives for achieving 'green' status, the PO must identify intervention and prevention based on the port's specific requirements.

• The POs are in charge of the baseline study, project report writing, and performance measurement report writing.

• For the projects/interventions to be completed, POs must submit all necessary reports to the appropriate Port Authority.

Major Port Authority (MPA)-

• To attain the desired goals, the MPA must complete the interventions/projects specified by PO based on the port's specific needs.

• The MPA can investigate opportunities for projects/interventions to be created, funded, and executed by any third party within the port premises to accomplish the desired results. These projects, however, will not be eligible for any cost recovery and incentive mechanisms.

• The MPA will analyze and evaluate the PO's submissions.

• MPA must identify interventions/projects for self-operated berths based on the port's individual requirements in order to achieve the desired outcomes for achieving 'green' designation. In this situation, the MPAs are in charge of conducting the baseline study, preparing the project report, and assessing the impact.

• MPAs must also identify green projects (such as purchasing electricity from bunkering facilities, renewable sources and so on) in areas where they are the primary managers.

• The MPA will submit the analyzed reports to the Ministry, together with the selected interventions/projects, and may request their feedback before approving their implementation.

Non-major port operators (NMPO)-

• To attain the desired goals, the NMPO must identify and finalize intervention and prevention based on the port's specific needs.

• The NMPO will submit the reviewed reports, as well as the selected interventions and projects, to the State Maritime Board or State Port Departments for final approval before they may be implemented.

State Maritime Board/State Port Departments (SMB) –

• To accomplish the desired goals, SMB will finalize the interventions/projects chosen by NMPO based on the port's unique requirements.

• In the instance of capital-intensive projects, the NMB will advise on the best financing option for the project.

Ministry of Ports, Shipping and Waterways, Government of India-

• The MoPSW will oversee the activities that will be implemented by various major ports in order to achieve the desired results.

4.3: Implementation process

The implementing agency must produce a thorough action plan that identifies projects based on port-specific requirements, propose financing options, and obtain approval for implementation from the relevant authority. To accomplish the desired outcomes for many stakeholders, the implementation roadmap has two primary components.

I. Finalizing the projects and interventions to achieve the targeted goals.

II. Steps to build the identified projects and interventions.

1. Steps to be followed for finalizing the projects/interventions to achieve the targeted outcomes

a. Conduct and complete the baseline study for all of the important parameters.

b. An unbiased third party will review and approve the base lining study.

c. The port operator/authority must submit an action plan to the related reporting authority based on the base lining research, suggesting several projects/interventions to achieve the desired goals.

d. The higher authority in charge will review and approve the action plan, as well as the projects/interventions recommended to accomplish the desired results, or may send it back for revision.

2. The implementing agency to implement the identified projects and interventions

a. To accomplish the targeted goals, the port operator/authority (depending on the implementing agency) must create a Detailed Project Report for the chosen green initiatives/interventions.

b. The Port Operator/Authority shall provide an impact assessment report, calculating the annual increase in operating costs and any amendments required from the Ministry of Ports, Shipping, and Waterways in order to achieve revenue neutrality.

c. The DPR and effect assessment report would be sent to MoPSW for any additional comments.

d. PAs should tell the MoSPW about upcoming efforts and expected outcomes. If necessary, the ministry may provide guidance on the efforts.

e. With the previous agreement of its Board/ Competent Authority, PAs may hire independent agencies to review and approve the financial requirements, desired outcomes of proposed projects/ interventions.

f. Following clearance of the intervention/project, vendors will be chosen through an internationally competitive bidding method or the port's applicable procurement standard. The projects can be carried out using either an operating or capital expenditure approach.

g. PAs may hire outside agencies to examine and approve the project's closure when it is completed.

4.4: Capacity Building and Monitoring

Port operators and authorities must establish dedicated units to ensure that port operations are safe, sustainable, and ecologically friendly. This section will be in charge of identifying, analyzing, and tracking the initiatives that will be implemented as part of the green policies. The Port Authority will guarantee that the members of this unit, as well as all other stakeholders, have the necessary ability and training to carry out their obligations. For this aim, port authorities may hire experts.

In addition, a robust monitoring mechanism must be devised to follow the status of the policy's activities across the ports. IT-enabled MIS-based monitoring will assist stakeholders in keeping track of progress and intervening as needed. In addition, a solid outcome evaluation methodology must be built in order to catch the potential advantages of the initiatives being implemented across multiple ports.

4.5: Health and Environmental consequences of shore power for vessel calling at major ports

4.5.1: Prior works

Many studies have proven that the health and environmental benefits of shore power outweigh the costs in North America, Europe, and Asia. According to a research on US ports, upgrading one-fourth to two-thirds of all vessels calling at US ports would result in a \$70–\$150 million annual social benefit. Calculating the environmental and economic benefits of onshore power in Europe while taking into consideration practical challenges. In the study, the health benefits of onshore were expected to reach €2.63 billion in 2010 and €2.93 billion in 2020. According to a UK research published in 2019, using shore power lowered NOx emissions by 91.6 percent, CO emissions by 75.6 percent, SO_2 emissions by 45.8%, and CO_2 emissions by 24.5 percent from berthed vessels. Many authors of the similar study also Shore power's ability to minimize at-berth CO_2 emissions was also investigated, and it was determined to be most effective in Norway (99.5 percent reduction), France (85 percent reduction), Japan (35.8% reduction), the United Kingdom (24.5 percent reduction), and Italy (27.3 percent reduction). Another study revealed that converting to shore power at Shenzhen's port in 2020 would lower SO_2 by 88 percent, NO_2 by 94 percent, PM by 95 percent, and CO_2 by 37 percent, although it appears to be a costlier plan than fuel switching. If 80 percent of container ships arriving in Shenzhen use shore power in 2020, the per-tonne expenses of decreasing NO_2, PM, SO_2, and CO_2 would be \$56 thousand, \$1.4 million, \$290 thousand, and \$2300, respectively. While many recent Asian shipping studies have focused on East Asia and China, few have addressed the air pollution problem caused by ocean shipping in India.

Two studies that we are aware of systematically analyzed emissions from ships in India's major ports. For evaluating auxiliary engine load factors, Joseph's first study used assumptions from the late 1990s. The authors conducted an analysis for the Jawaharlal Nehru Port in 2006, determining the contributions of total suspended particulate matter, respirable particulate matter, and SO2 for various port activities (port operations, construction, and road transport), and discovered that TSP contributions dominated, accounting for 68.5 percent of the total pollutant load, with SO2 contributions accounting for the smallest contribution (5.3 percent). The article discovered that the road network released the most NOx, whereas the maritime industry emitted the most SO2 in the port.

The second research looked at emissions in Kolkata's port from 2013 to 2014. The authors calculated annual emissions for NOx, SOx, PM10, PM2.5, carbon monoxide (CO), hydrocarbons (HC), and CO2 during ships' various activity modes (reduced speed zone, maneuvering, and hoteling) for Kolkata port, and found that NOx and SO2 emissions were the most prevalent among pollutant species. The researches attributed the excessive emissions to the shipping channel's length, the use of bunker fuel, vessel non-compliance with IMO emission rules, and the berth's long turnaround time. The study is limited because the authors only looked at emissions from this one port from 2013 to 2014. Between 2013 and 2017, shipping activity at Kolkata Port rose by 35%, and emission at the port are likely much higher than those indicated in the paper. Finally, the Kolkata Port Trust is responsible for two significant facilities., namely,

(a) Kolkata Docking System

(b) Haldia Dock Complex, not to have included HDC, which may also have resulted in an underestimate of emissions.

4.5.2: Major ports

Figure 4, The map depicts India's 12 major ports, which are overseen by the Ministry of Shipping through their individual Port Trusts. These are the ports that the huge cargo vessels that are the subject of this research primarily visit. From April 2021 to March 2022, they handled 719.38 million tonnes of cargo. From April 2021 to March 2022, the Port of Los Angeles (POLA) handled 295 million tonnes of cargo.

Fig 4.1: Geographic location of India's 12 Major Ports ~7500 km coastline.

There are nearly 200 non-major ports in addition to the major ports, some of which are not suited to handle large cargo vessels. Many fishing vessels dock in small, unofficial ports, contributing to pollution near these ports. However, it is unclear whether they produce enough electricity for hoteling demands or whether they could be switched to shore power at a profit. Small fishing vessels and non-major ports are not included in our research because the focus is on lowering pollution by converting to shore power at big ports.

4.5.3: Vessel call information

We gathered vessel activity data for all 12 main ports in India through email and meetings with stakeholders at various levels in the MoS, GoI, Port Trusts, Indian Ports Association, Indian Coast Guard, and Indian Army. Our vessel call dataset contains detailed information on ships, such as the ship's IMO registration number, Maritime Mobile Service Identity, a unique nine-digit number that identifies each ship's Automatic Identification System station, Vessel Name, Vessel Type, Gross Register Tonnage, Deadweight Tonnage, Flag, Cargo information (for some ports), pilotage time, and berth arrival and departure times.

These figures are for the very same one-year period, from March 2021 to March 2022. There were some vessel calls at ports where the IMO registration number and MMSI information were absent in the raw data. We designed a web scraper in the Programming to find the vessel IMO number, vessel age, MMSI number, and vessel type based on vessel name, GRT, and DWT from online data at Marine Traffic. Only vessels that stay in port for more than 5 hours but less than 230 hours, the 98 percentile of all port calls, are considered. The lower restriction excludes ships which do not spend enough time in port to be linked to shore power, while the upper bound excludes ships that are in port but not active.

4.5.4. Emission Calculation

The emissions for OGVs for each vessel call were estimated according to the following equation:

$$E_{i,j} = EF_i \times A_j \times t_j$$

Where,

$E_{i,j} =$ Total emissions, in tonnes, for pollutant **i** ($PM_{2.5}$, SO_2, NO_x and CO_2) for vessel call **j**
$EF_i =$ Emission factor for pollutant **i** expressed in g $(kWh)^{-1}$ of electricity generated by the auxiliary engine.
$A_j =$ Auxiliary engine's actual operating load for vessel call **j** (in kW) based on the vessel type and its size.
$t_j =$ the time (in hours) the vessel spent hoteling during vessel call **j.**

The emission factors for PM2.5, NOx, SO2, and CO2 were derived from the EPA's recommendations for preparing mobile emissions inventories.

By subtracting berth arrival time from berth departure time from databases, the total time spent by a vessel hoteling at the port may be calculated. Finally, we multiply the emission factors by estimates of the hoteling load (in kWh) for various vessel types and sizes to obtain emissions for individual vessel calls. While we calculate emissions for each vessel call, the findings may be broken down by vessel, vessel type, and year. Both RO and MGO emission calculations can be done.

4.5.5: Auxiliary engine power

The auxiliary hoteling loads of a vessel of a certain type and size were calculated by multiplying the total berthing duration (in hours) as well as the auxiliary engine load during operation (in kW). Our computation is predicated on the assumption that a vessel's auxiliary hoteling load scales linearly with its deadweight tonnage capacity. We examined the ship sizes and ages in our dataset to those that arrived at POLA and Port of Long Beach for auxiliary engine load estimates. We discovered that the vessels in our database are similar in age to those in those ports. As a result, we considered that applying the POLA and POLB's 2022 emissions inventory's link between vessel size and auxiliary loads was suitable.

4.5.6: India's state grid emission factors

We expected that a vessel would use the same amount of energy from shore power as it does from its on-board generator at most. The World Bank estimates that India suffers 19 percent transmission and distribution losses, including theft. The precise amount of technological losses is uncertain. T&D losses are estimated to be 10%. Coal accounted for 76 percent of India's total electrical generation in 2017–2018. In our calculations, we estimate that coal provided 76 percent of India's electricity in 2017, but that coal provides all of its load-following electricity, which is relevant to the issue of shore power. Apart from coal, gas generates 4% of total energy; the balance comes from non-emitting sources.

We overlook air pollution from natural gas-fired power plants. We presume that all electricity market emissions come from coal combustion because all other sources of power in India create no emissions from combustion.

For shore-based electricity, which gives yearly coal-fired power plant PM2.5, SO_2, NO_x, and CO_2 emissions at the energy hub level for 2012.

We aggregated coal power plant emissions at the state level for India using the latitude and longitude of coal-fired generating units. To calculate total power generation in Indian states in 2012, we used data from the Central Electricity Authority. To arrive at state level PM2.5, SO_2, NOx, and CO_2 emission factors (in g (kWh)1) for electricity generation, we divide emissions from coal-fired power generation in each state by total electricity generation in the same state.

Chapter V

Indicative list of initiatives in India

There are numerous options for putting the measures in place to achieve 'Green Port' status. The ones proposed by the Committee are designed to mitigate air pollution, minimize carbon emissions, reduce and recycle waste, optimize port resource management, maintain marine biodiversity, and increase overall efficiency. However, the following list is merely illustrative; ports may pursue any projects that will ultimately aid in achieving the goals outlined in the draught GPP paper.

5.1: Interventions to Reduce Carbon Emissions

5.1.1: Gradual shift of Energy Source: Transition towards renewable source of energy

The use of nonrenewable energy sources results in significant carbon emissions. In this case, Group Captive Renewable Energy Projects can be used to replace up to 60% of the electricity consumed by ports. Under the 'Captive Status' approach, the Port authority can acquire 60%+ electricity through a tariff-based competitive bidding process based on SECI's standard bidding formats. To be considered a 'captive,' the port authority must invest and own at least 26% of the equity share (and voting share). Port Authorities may explore any of the following options for renewable power projects:

- Implement renewable energy sources using an EPC model on Port-owned land.
- Through PPPs, where the concessionaire invests.
- Participation in joint ventures with central/state PSUs, with port land considered equity
- Concessional land should be made available to renewable energy developers on a lease basis whenever possible.

Other viable methods for transitioning to renewable energy sources may be considered by the Port Authorities. Port authorities, for example, might buy green energy from power exchanges depending on their demand.

Example: Since 2016, the world's largest port-based 9.5-megawatt peak solar energy producing facility has been operational at the Jurong Port in Singapore.

5.1.2: Energy demand optimization: Switch to energy efficient equipment for reducing energy demand

The Bureau of Energy Efficiency may work with the Port Authority and Port operators to implement a Perform, Achieve, and Trade programme for all ports. To meet the PAT targets set by BEE, the MPA and PO can conduct annual energy analysis of the port and undertake energy saving strategies such as installing 5-star rated electronic systems and converting to LED lights in the port premises.

The MPA and POs may be given the option of trading PAT, which will eventually encourage them to use more fuel saving electrical instruments.

Example: Energy audit systems, improved operating efficiency, and other steps have been implemented by EU ports to minimize energy consumption. Aluminum, Cement, Chlor-Alkali, Fertilizer, Paper & Pulp, Iron & Steel, Thermal Power Plant, and Textile are among the 11 industries that have saved 1.46 percent of India's power consumption and 2.5 percent of CO2 emissions.

5.1.3: Use of Non-conventional sources of fuels: Encourage usage of nonconventional sources of fuel for equipment, vehicles

Use of non-conventional sources of fuel for port equipment and vehicles adds to their carbon footprint. Certain interventions such as i) Electrification of berth cranes (Quay Gantry Cranes, Mobile Harbor Cranes) or retrofitting for use of LNG, ii) Electrification of Terminal Equipment (Cargo handling equipment and Yard equipment – forklifts, straddle, carriers, RTGs) or retrofitting for LNG, iii) Retrofitting of Intra-terminal trucks for LNG/ CNG/Hydrogen or Use of Electric Vehicles, iv) Creating EV charging infrastructure, v) Mandatorily providing shore power to ships, etc. may also be explored by the Port Operators to reduce carbon emissions.

Example: Port of Marseille, Hamburg and few other EU ports have already electrified terminal transport and stacking equipment. California ports have taken multiple initiatives to reduce at-berth emissions from its vessels' auxiliary engines. California ports have mandated the use of shore side power to ensure return on the investment.

5.2: Interventions to Mitigate Air Pollution

Reduce Air Pollutants

The PO can implement certain interventions to reduce air pollutants in the port premises, such as installing a dust suppression system with the ability to recycle spraying water, using a spill-proof conveyor for dry cargo transfer, installing sensors to ensure dust emission is within the allowable limits, replacing HFO with marine gas oil, and so on.

Additionally, carbon offset measures such as tree planting on port property and increased use of recyclable/biodegradable products may be implemented to reduce air pollution in the port region.

Example: The Vostochnaya Stevedoring Company (Russia) has introduced two mobile dust suppression machines, which are designed to reduce coal dust concentrations in the air at all phases of the working cycle, particularly during coal handling and storage at the yard.

5.3: Interventions to Reduce and Recycle Waste

Waste-recycle and waste- management

The PO may choose interventions (such as waste to energy or bioremediation) aimed at Zero Incineration, Zero Waste to Landfill, Zero Unauthorized Disposal, and Zero Effluent Discharge in order to recycle waste and establish a zero waste system. POs, MPAs, and non-major ports may construct sewage treatment plants on their property. Ports must build suitable reception facilities to allow ships to meet MARPOL's garbage discharge requirements.

POs/MPAs/Non-major Ports may design site-specific water management plans to treat and recycle a minimum 25-50 percent of wastewater in order to minimize and recycle water usage.

Example: Trash Framework Directive 2019/883 was created by the EU to guarantee that waste disposal, recycling, re-use, recovery, and separation programmes are implemented at all EU ports. The Port of Kiel has completed a wastewater treatment facility to improve Baltic Sea protection.

5.4: Interventions in Resource Management

5.4.1: Usage of fresh water

The MPA may look into the possibility of setting up the green desalination system for water for port operations in order to reduce the use of fresh water. To recover groundwater and reduce freshwater usage, POs may construct rainwater gathering systems.

5.4.2: Usage of dredged material

Wherever practical and economically feasible, the potential of reusing dredged material will be investigated.

Example: A new desalination facility in Antwerp's port will pump up brackish dock water and transform it into high-quality processed water for the region's chemical industry.

5. 5. Interventions to Preserve Marine Biodiversity

POs/MPAs/Non-major Ports may be required to achieve zero biodiversity loss in order to protect marine biodiversity (where relevant). The MPA may also establish ocean-economy innovation networks, such as Oil Spill Response Facilities and Oily Waste Reception Facilities, to improve catastrophe resilience and response.

Example: The Port Authority has made steps to prevent dragnet fishing around the port of Cava in order to protect and increase the number of animals there. Global Ports provide reception facilities in accordance with MARPOL requirements to guarantee minimal biodiversity effect.

5.6: Interventions to Improve Productivity to reduce GHG emissions

Improving productivity will almost certainly result in lower GHG emissions. The MPA might make it mandatory

1. An online port management system that will record all port calls, nautical services, cargo, and assets, as well as give operational decision support.

2. To improve port productivity, a digital asset management solution for ports is needed to monitor asset health and facilitate preventative maintenance (e.g., smart quay walls).

Example: Port of Rotterdam has implemented several digital solutions, such as Postmaster, PortXchange.

The PO could also ensure that all employees undergo annual safety training and that at least one safety audit is performed each year, resulting in zero accidents. In accordance with global ports, the ports must adhere to strict health and safety rules within the port grounds.

5.7: Eco berthing in India

With vessels hooking into renewable energy at Indian ports, shipping has become a little greener. When you hear the word "shipping," images of stately vessels floating through the sky and into an even bluer sea come to mind. However, the industry uses heavy fuel oil, which emits Sulphur oxide, which causes acid rain. As a result, India's new "Green Port" project is a step toward more responsible maritime transportation.

All of the country's state-owned ports now function on renewable energy, making it the first in the world. According to sources, solar and wind energy power ports at Kandla, Mumbai, Thoothukudi, Kochi, Chennai, Visakhapatnam, Kolkata, Paradip, Mormugao, and Mangaluru nearly a couple of years after the project was first announced. Docked ships will be able to use the port's green energy to offset carbon emissions, which are typically 5x-10x higher than the port's emissions. The Green Port project includes obtaining equipment for monitoring environmental pollutants and dust suppression systems, as well as establishing waste-water treatment plants, all with a goal of cleaner day-to-day operations.

Green Port brings us closer to the Sagar Mala logistics development programme, which is part of a bigger overhaul aimed at increasing shipping's diminishing share of cargo flow. The country's cargo flow is handled by less than half of the country's new green ports, that are the major ports. Construction of the new berths, last-mile rail connectivity, equipment upgrades, dredging, and digital solutions are all part of the bigger Sagar Mala development.

Chapter VI

Suggestion and Conclusion

To overcome the limits of depending just on restricted data or the planners' subjective opinion, a mixture of top-down strategic focuses and bottom-up assessment information is required to improve planning effectiveness. Furthermore, while some organizations, such as the PIANC, have begun to link supply chain problems with port design, the majority of present approaches remain focus on the port. Port sustainability planning should focus more on the collaborative research-practice maritime supply chain to steer the maritime industry toward sustainability, given that ports are the nodes of logistics chains in the context of globalization and larger-sized vessels.

Furthermore, because "planet Earth is an end-in-itself" and humans are part of nature and ecosystems, the preservation of natural ecosystems has long been regarded a vital to sustainability. Based on the findings of the review, it's found that present port sustainability techniques have shortcomings in terms of capturing the ecological nature of sustainability. Because of human preferences, present sustainable port design concepts, which are oriented at meeting human wants, makes it difficult to maintain natural resources. The recent failure of eco-port planning to promote nature conservation may result in the slow advancement of the sustainability strategy. Although green port design enhanced environmental consciousness, a long-term strategy, meaning green development, has yet to be implemented.

Because of its eco-centric theoretical foundations and goal of conserving natural resources and biodiversity, the green development method has shown to be a good alternative for achieving sustainability. Fortunately, the chosen sustainability method was introduced in the real estate business in 1998, allowing ecology to be integrated into development. Green development has also been employed by several countries and towns to transform their growth; for example, China has made green development an important development path.

The green port is suggested as a good way to sustainability in this study, and the inclusion of green development in the theoretical foundations and aims may lead to more precise and thoughtful consequences., as follows:

• Integrating ecological concerns such as biodiversity, natural resource protection, and environmental risks posed by oil spills and non-routine discharges into port development.

• In port scoping, consider the logistic chain from such a source to a destination to increase connectivity and provide value.

• For port planning, combining the top-down strategic sustainability goal with scientific bottom-up assessment information.

6.1: Identified Challenges and Future Outlook

Because ports are commercial enterprises that are not driven to invest money unless it is absolutely necessary, it is critical to comprehend the challenges and restrictions, as well as possible policy and operational circumstances. These include both the use of current best practices and the imposition of stricter regulations to encourage the faster adoption of new technologies and the transition to greener practices. This project intends to increase knowledge within a core strategy to aid decision-making, as well as to assess the current situation and determine whether more can and must be done.

The project's breadth and depth of chapters demonstrates the richness of knowledge accumulated by scholars in recent years about the environmental concerns created by and confronting the maritime sector, as well as current and potential remedies. While more best practices sharing and technical advancements are needed, there is already enough knowledge to make significant progress in reducing environmental externalities. Under current conditions, decarbonization of the shipping sector is unfeasible without a significant fall in shipping volume. At sea, switching a portion of the world fleet to LNG and widespread adoption of slow steaming are viable possibilities, although they would still fall well short of the IMO's 50% target. It is possible to take significant actions in ports, which are the primary focus of this project, such as switching in-port activities to electricity (potentially generated onsite through wind turbines and solar panels, especially in countries where the national electricity grid is not currently generated by sustainable sources), and reducing ship emissions at the port through a combination of slow steaming in the port area, LNG use, and cold ironing.

The final question to ponder is why is sustainability always placed last? We must confront this question as academics, even as we ask it of industry and policymakers. Is pollution reduction merely a potential add-on that should be studied and considered, or should it be a mandatory action with the additional cost internalized? Because of the container revolution, sea transportation expenses now account for only a small portion of total goods costs.

Transport costs account for only 3% of the value of commodities globally, and even less for many consumer goods; thus, a rise in freight charges, such as a bunker levy to encourage the switch away from HFO, may easily be absorbed. The industry outcry that followed the Plimsoll Act of 1876, one of the first measures of maritime regulation, emphasizing out that, as with most laws, the business adapted and life went on after it was adopted. A similar argument may be made in the case of SECAs. This is not to say that quick regulation is the best solution to every new problem, but air (and other) pollution from the shipping sector is not a new problem, and the abundance of research done and proved in this volume is already enough to guide action. The work on this project shows that we know what has to be done and also how to achieve it, at least from the port's standpoint. Action might be mandated by port authorities, governments, and regulators.

6.2: Action Currently Being Taken by Policy Makers and Regulators

The International Marine Organization (IMO) is the United Nations' maritime branch, which was created in 1948 and came into operation in 1958. Its job title is "responsible for the safety and security of shipping, as well as the prevention of ship-related maritime pollution." An IMO convention is usually considered in force once a certain number of member states have ratified it (India has been a member since 1959), but it does not apply to countries that have not enacted it, and enforcement is left to individual member states rather than the IMO, resulting in varying levels of enforcement.

The International Convention for the Prevention of Pollution from Ships, which was adopted in 1973 but only came into force in 1983 due to ratification issues, is the most important convention here. MARPOL provides a global guideline to prohibit ships from polluting the ocean due to operational or unintentional causes. The original annexes were mainly concerned with preventing

contamination of the marine environment, however they have since been modified, and in 2005, MARPOL Annex VI went into effect with the goal of reducing air pollution from ships.
Annex VI has been revised several times over the years, with the most recent change taking effect in 2010 with the goal of gradually imposing more restrictive limitations and introducing emission control zones. The ECAs are found in the North Sea, Baltic Sea, North America, and the Caribbean region of the United States. Because of their prominent sulphur limit of 0.1 percent as of 2015, ECAs are sometimes referred to as SECAs, however North American ECAs also have NOx regulations.

Furthermore, the amendment cut the worldwide sulphur cap from 3.5 percent to 0.5 percent by 2020. Carriers combat this by switching to low-sulfur fuels or installing exhaust scrubbers. In the industry, there has also been considerable concern about whether enough low sulphur fuel could be produced if laws compel increased use. However, it's important to remember that, from another perspective, the SECA limits are quite weak. To emphasize that the lowest permissible sulphur level in SECAs is still 100 times the allowed sulphur level in road truck fuel. Furthermore, the present SECA locations do not cover the entire globe, notably impoverished places such as Asia's densely concentrated maritime channels, and there are none in Africa or South America.

Regulation 13 of the new MARPOL tightened the restrictions on NOx emissions. NOx limitations are imposed on ships based on when they were built, with Tier I, Tier II, and Tier III being the most stringent. Other standards concern vessel efficiency: the EEDI and SEEMP were agreed upon in 2011 and accepted into MARPOL Annex VI, requiring new ships to follow the EEDI and all ships to follow the SEEMP. Furthermore, the present SECA locations do not cover the entire globe, notably impoverished places such as Asia's densely concentrated maritime channels, and there are none in Africa or South America.

Despite shipping's considerable contribution to global GHG emissions, IMO regulations have focused on SOx and, more recently, NOx. However, there has been no restriction or target on CO2. While it's logical that industry players and organizations prefer global laws to a patchwork of national and local regulations. The IMO has been looking into the potential of market-based mechanisms to reduce CO2 emissions, such as emission trading schemes and bunker fuel levies, as an alternative to regulation. These have the advantage of being uniform across all carriers, providing more market certainty and less likely to distort competition. The IMO is still debating these processes, and no action has been done as of yet.

The International Maritime Organization (IMO) stated in April 2018 that the shipping industry has agreed to reduce carbon emissions by 50percent by 2050. Setting a goal for the very first time is a good start, but history indicates that good intentions don't always convert into action. The long period allows for the deadline to be postponed or further modified, and the fact that the US was not in agreement to limit compliance with the aim. As a result, reaching this ambitious goal will be difficult without clear and strong worldwide laws.

More stricter standards can be implemented in addition to the IMO convention criteria. The EU White Paper on Transport planned to reduce carbon emissions from transportation by 60% by 2050, using techniques like cutting "CO2 emissions from naval bunker fuels by 40%." ECAs in the English Channel, North Sea, and Baltic Sea were specified in a directive released in 2005. Directives encouraging cold ironing and LNG were also enacted by the EU.
According to a directive 2014 on the deployment of Alternative Fuel Infrastructures. Only if there is no demand and the cost are disproportionate to the benefits, especially environmental benefits, such shore-side electrical supply shall be established as a priority in ports of the TEN-T Core Network, as well as in other ports, by 31 December 2025." Member states must also "ensure, through their national policy frameworks, that an appropriate number of LNG refueling points are installed at sea ports to enable LNG inland waterway ships or sea-going vessels to flow freely throughout the TEN-T Core Network by 31 December 2025 at the latest".

In January 2018, the EU introduced the MRV (monitoring, reporting, and verification) regulation, which requires mandatory monitoring of Co2 emissions by vessels larger than 5000 gross tonnage calling at EU ports as a first step toward potentially setting targets, but no limits or actions have yet been established. These, however, only apply to vessels and vessel operators, not to the ports itself, which are the project's main focus.

National, regional, and worldwide port organizations, in addition to governments and regulatory authorities, are attempting to make port activities more sustainable. Environmental management, regulations, and planning in European ports are promoted by the European Sea Ports Organization. In order to promote the ESPO Green Guide, the organization found the Eco-Ports Foundation in 1999, a network of European ports dedicated to identifying the key environmental consequences of port activities, services and products. Air quality, energy usage, relationship with local community, noise, garbage/port trash, ship waste, port growth, water quality, dust, and dredging activities are the top ten environmental priorities of ESPO ports.

In America, the American Association of Port Authorities, which has 150 members from North, Central, and South America, has produced the Environmental Management Hand initiative, a handbook for environmental management. Various multinational initiatives are paving the way to a greener future. In 2008, the International Association of Ports and Harbors asked its Port Environment Committee to develop a framework to help ports in combating climate change in partnership with regional port organizations.

As a result, the C40 World Ports Climate Declaration was adopted in 2008, resulting in the formation of the World Port Climate Initiative, which now includes 55 ports from around the world that pursue various green initiatives such as offering discounts to vessels scoring above a certain threshold on the Environmental Ship Index. With the advent of the World Ports Sustainability Program in 2018, this project has grown. The IAPH, the AAPA, the ESPO, the Worldwide Network of Port Cities, and the World Association for Waterborne Transport Infrastructure have collaborated on this project.

The initiative strives to adhere to the United Nations' 17 Sustainable Development Goals. Resilient infrastructure, climate and energy, community engagement and port–city dialogue, safety and security, and governance and ethics are the five main themes. While programmes like this that focus emphasis on more environmentally friendly operations at ports through sharing best practices and emission reduction commitments are desirable, the voluntary nature of such schemes means that major emission reductions are still delayed. GHG emissions reductions via voluntary port programs are still minimal, and it will be a long time before they are both rigorous and widely accepted. Given the commercial nature of seaports, this is understandable, but regulators and policymakers must be prepared to take more tangible action, not only nudge and incentivize.

6.3: Draw backs to Indian Ports

Poor collaboration with shipping firms and other supply chain participants were highlighted as important problems for the sustainable growth of ports in the Association of Southeast Asian Nations, notably in Asia and the Indian subcontinent. Researchers discovered little interest in offering incentives to shipping businesses to utilize low-sulfur fuel, lower speed near ports, and adopt environmentally friendly vessel designs. Slow steaming, for example, has been studied as a potential green port policy in Asian ports.

6.4: Conclusion

Challenges in globalization and global sustainability motivate practitioners and scholars to develop proactive and collaborative port sustainability planning. There is currently no uniform or cohesive policy in place for port sustainability-oriented planning. This study adds to the assessment by examining and discussing existing representative sustainability techniques for port planning. Insights from our broad literature review indicate the following:

(1) For port-specific growth, present sustainability approaches in port planning are confined to specific concerns, historical data, and subjective opinion.

(2) Environmental considerations were prioritized in approaches for sustainable port development, eco-port planning, and green port planning, while ecological issues were overlooked.

(3) Current sustainable port development practices, which are aimed at meeting the demands of current and future generations, are not a good choice for long-term sustainability;

(4) Green port planning overlooked the impact of green development on environmental sustainability. We picked green port planning as a preferable technique for sustainability and gave more conscious connotations for consideration after comparing the present sustainability approaches for port planning.

This study provides a useful analysis to aid in understanding the current state of port sustainability planning and encourages in-depth consideration of port sustainability. Nonetheless, we would like to see a broader and more in-depth discussion on this subject in order to progress toward the long-term aim of sustainability. Innovative sustainability education will be critical in this regard.

The suggested concept of a green port will have an impact on future approaches and methodologies from the perspectives of planning objectives, planning areas, planning procedures, and priority projects. It will be beneficial to establish a collaborative and cooperative research–practice network in shipping, port, maritime logistics. A broader conversation would include considering other variables such as economic effect and technology innovation in order to learn more about port sustainability strategy. Furthermore, a lot of ethical inquiries into current research and practices are needed for greater teaching about sustainability in ports, which may inspire creative thinking.

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