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POLICY FRAMEWORK FOR BUILDING A GREEN PORT IN WARRI SEAPORT, NIGERIA

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ABSTRACT

This study seeks to establish a policy framework for building a green port in Warri Seaport, Nigeria. The aim of this research work is to identify the importance of green ports to the development of the maritime industry in Nigeria, also to reduce the negative impact of shipping operations to the marine environment and how sustainable shipping operations can reduce climate change. The researcher adopted **a** survey research design, with a sample size of 300 respondents. The Spearman Rank Correlation Coefficient was employed to evaluate the hypotheses of the empirical investigation. The findings indicate a statistically significant association between the dependent variable and the explanatory factors, we found out that different ports may face challenges in implementing a proper digitalization level that is influenced by many factors, including operations, environment, energy, safety and security, and human resources, and is possible to adopt clean energy sources. However, the study recommends that a robust policy framework for building a green port in Warri Sea port, Nigeria, should be enacted, which will increase the revenue drive of ports in Nigeria, improve air quality and reducing noise pollution in ports, such law should encompass environmental assessments, renewable energy investments, smart technology implementation, stakeholders' collaboration, and community engagement. These recommendations will not only enhance operational efficiency but also align Warri Port with global sustainability goals.

Key Words: Technology, Green, Smart Port, Policy Framework, Energy.

1.0 INTRODUCTION

As major points and imperative centers for cross-border trade and marine development and improvement, seaports consume a colossal amount of energy and are one of the main sources of carbon emissions. Within the setting of "carbon peaking and carbon neutrality," it is imperative to prioritise the inclusion of improved energy management options for the development of green ports in Warri ports and all seaports in Nigeria, in order to improve the air quality and minimize noise pollution. The application of renewable energies like solar and wind, as well as other clean sources of power, which include hydrogen gas, such as common gas and hydrogen, is getting to be progressively used, because of its importance. Furthermore, the utilization of sophisticated technologies and other progressed innovations is on the increase, such as shore power, electric yard, and bridge cranes are on the rise. As we face the pressing challenges of climate change and environmental degradation, establishing a robust policy framework for building a green and smart port is imperative. This framework should encompass a multifaceted approach that integrates economic development, environmental protection, and social equity. Legislation aimed at promoting renewable energy sources is critical. Policies that incentivize solar, wind, and other renewable technologies can significantly reduce greenhouse gas emissions. For instance, the implementation of tax credits for renewable energy investments can accelerate the transition away from fossil fuels (International Renewable Energy Agency, 2021). Promoting energy efficiency in seaports and industries is essential. Regulations that mandate energy-efficient appliances and building codes that support sustainable architecture can lead to substantial energy savings. The U.S. Department of Energy's Better Buildings Initiative serves as an example, aiming to improve energy efficiency in commercial buildings and seaports by 20% over the next decade through best practices and innovative financing (U.S. Department of Energy, 2022). Additionally, fostering sustainable transportation options plays a vital role in reducing urban emissions, use of Power-intensive terminal equipment, In-port vessel operations and Ship bunkering (refueling). Policies that promote public transit, cycling infrastructure, and electric vehicle incentives can mitigate reliance on gasoline-powered transportation. The Global Innovations for Climate Action outlines various strategies, including improved public transit funding and infrastructure development, to encourage greener commuting practices (World Resources Institute, 2023).

The transition towards a sustainable maritime industry is imperative in the face of climate change and environmental degradation. Building a green port encapsulates the principles of sustainability, reducing carbon footprints, and promoting environmental stewardship, while maintaining economic efficiency. A green port integrates renewable energy sources, efficient waste management systems, and innovative technologies to minimize its ecological impact. Green ports utilize renewable energy for power operations. By harnessing wind, solar, and tidal energy, ports can significantly reduce their dependence on fossil fuels. For instance, the Port of Rotterdam has committed to using hydrogen as an energy source, demonstrating a practical pathway toward sustainability (Port of Rotterdam Authority, 2022). Such initiatives not only decrease greenhouse gas emissions but also enhance energy resilience. Implementing efficient waste management systems is vital. A green port must prioritize recycling, composting, and waste-to-energy technologies. The Port of Barcelona exemplifies best practices in waste reduction by actively engaging in comprehensive recycling programs and aiming for zero waste initiatives (Rolán et al, 2019). These efforts not only foster environmental preservation but also promote a circular economy within the maritime industry.

The adoption of automated systems and data analyses can optimize operations, minimizing unnecessary energy usage and maximizing efficiency. As global emphasis on sustainability intensifies, the maritime industry is increasingly adopting green technologies and practices. Nigeria, with its extensive coastline and bustling ports, is positioned to leverage this movement through the establishment of a Green Port Policy (Adewale, 2022). This policy, aimed at minimizing environmental impact while maximizing operational efficiency, is vital for the country's economic and ecological future. Egole, (2024) opines that Nigerian Ports Authority has developed a port emissions inventory aimed at tracking and reducing greenhouse gas emissions across the country's port activities. He said that it would be a comprehensive tool to measure and monitor emissions from all port-related activities, including vessels at berth, cargo-handling equipment, and port service vehicles. He stated that climate change, driven by increased greenhouse gas emissions, poses serious threats, including rising sea levels and extreme weather events, which endanger Nigeria's coastal and port infrastructure as well as surrounding communities. "To address these environmental challenges in maritime operations, the Nigeria Port Authority will develop a comprehensive Port Emissions Inventory, aimed at tracking and reducing

GHG emissions across Nigeria's port activities. The Green Port Policy in Nigeria stems from the urgent need to address the environmental degradation associated with port operations. Traditional port activities contribute notably to air, noise and water pollution, habitat destruction, and greenhouse gas emissions—issues that are especially pronounced in the highly trafficked ports in Nigeria. A dedicated policy would set clear guidelines for implementing environmentally friendly practices, such as the use of renewable energy sources, waste management systems, and emissions reduction technologies. Adopting a Green Port Policy could significantly bolster Nigeria's attractiveness to global trade partners and investors. According to the World Bank, green practices in port operations can enhance efficiency, reduce operational costs, and improve competitiveness. By integrating modern technologies such as automated cargo handling systems, documentation and electric vehicles in port logistics. (World Bank, 2021). Nigeria could streamline its maritime operations, ultimately fostering economic growth. Furthermore, such a policy aligns with Nigeria's commitments to international environmental agreements and national sustainable development goals. The Nigerian government, through agencies like the Nigerian Ports Authority (NPA, 2022), can implement regulations for cleaner shipping practices and incentivize port operators to adopt green technologies.

The concept of a Green Port Policy in Nigeria is increasingly becoming essential in the quest for sustainable maritime operations. As one of Africa's largest economies, Nigeria's ports play a vital role in trade, facilitating over 70% of its imports and exports (NPA, 2020). Nigeria has made moves towards this direction, aligning with the National Environmental (Noise Control) Regulations of 2009 and the Nigeria Maritime Administration and Safety Agency (NIMASA) initiatives aimed at promoting sustainable shipping practices, but yet to come to light (Adeyemo et al., 2021). By implementing renewable energy sources, such as solar and wind, and utilizing energy-efficient technologies, Nigerian ports can significantly cut down their carbon footprints. Moreover, the Green Port Policy promotes the adoption of eco-friendly transportation modalities, such as inland waterways, which can alleviate road congestion and reduce air pollution. According to the NPA (2021) report, boosting the use of barges and ferries not only results in environmental benefits but also enhances the efficiency of cargo movement. Furthermore, stakeholder engagement is crucial in the successful implementation of a Green Port Policy. Collaboration among government agencies, port operators, and the private sector can foster innovation and

compliance with environmental standards. International partnerships could also play a pivotal role in technology transfer and capacity building, as evidenced by successful Green Port initiatives in countries like Norway and the Netherlands. (Oruonye and Akinwumi, 2019),

1.1 STATEMENT OF PROBLEM

However, the environmental degradation associated with traditional port operations poses significant challenges, necessitating the adoption of a Green Port Policy that emphasizes environmental sustainability, economic viability, and social responsibility. Challenges bedevilling the implementation of green port policy in Nigeria include, but not limited to lack of adequate regulatory frameworks, finance and enforcement mechanisms. The Nigerian Port Authority, does not have a policy to reduce green emissions from vessels in port (Egole, 2024). Therefore, this research work tends to assess the impact of a policy framework for building a green and smart port in the Warri seaport, Nigeria.

1.2 LITERATURE REVIEW

This research work is hinged on the Game theory by John von Neumann and Oskar Morgenstern in the 1940s, it is a mathematical framework for analysing strategic interactions among rational decision-makers, which has notably influenced the development of ports and maritime economics. In the context of port development, game theory provides vital insights into the interactions between various stakeholders, such as port authorities, shipping companies, logistics providers, and regional and local authorities. By analysing these relationships, stakeholders can make informed decisions that optimize resources and enhance competitiveness. For instance, when developing new port facilities and policies, authorities must anticipate the responses of shipping companies to capacity expansions or policy changes, which may influence investment decisions. This theory concerning port development underscores its significance in shaping strategic interactions among stakeholders. As global trade continues to evolve, the adoption of game-theoretic principles will remain crucial for optimizing port operations and enhancing competitiveness in an increasing economy (Hokey, 2022).

In recent years, there has been increasing awareness of the need for sustainability in global trade and maritime operations. Nigeria, with its extensive coastline and bustling ports, is at a critical

juncture to adopt a Green Port Policy (GPP) that not only enhances its economic potential but also minimizes environmental impacts. Global literature emphasizes the necessity of GPP as a framework for integrating environmental considerations into port operations. According to IMO (2019) report, sustainable ports improve resource efficiency and comply with international environmental standards. Various studies highlight that GPP can significantly reduce carbon emissions and promote alternative energy sources (Cagno et al., 2020; Hsu et al., 2021). Ports in the Mediterranean region illustrates how strategic implementation of green initiatives led to improved air quality and local biodiversity (Dumont et al., 2020). In the Nigerian context, the discussion surrounding GPP is relatively nascent. However, literature underscores Nigeria's urgent need for sustainable practices in its maritime sector. A study by Oko et al. (2022) reveals that pollution from shipping operations has dire implications for coastal communities. Implementing a GPP would benefit not only the environment but also public health and the economy. A successful GPP in Nigeria would encompass several elements: the promotion of clean technologies, sustainable waste management, and community engagement. The establishment of partnerships with international organizations can facilitate knowledge transfer and funding opportunities essential for implementing green technologies.

Rodrigo et al. (2020) opined that an improvement in the profitability of the port sector will have positive impact in the overall port operation. Consequently, the application of the green and smart port concept in the industry is particularly important. Hence, the term “smart port” was born, which has generated great attention in all the active ports, as it is the basis for the development and continuation of any future port. Therefore, the port must be sustainably integrated with the environment, ensuring a space that can be used by residents, strengthening its relationship with the sea and making it possible to benefit from it. Ogola et al (2024) furthermore affirmed smart ports as a way of having full automation, great productivity and greening services such as a port operation structure, port logistics equipment and infrastructure. The smart port is relying on the application of innovative technologies to convert port services into interactive and dynamic services that are more effective and apparent, While the aim is to optimize customers’ needs and wants. Furthermore, from environmental protection perspective (Szaruga., 2021), the sustainable development of the port establishes its main pillar as well as its orientation concerning the city and its citizens in order to guarantee the high quality of space and facilities. New technologies being

considered contain Artificial Intelligence (AI), Block chain, and Internet of Things (IoT) (Jun. 2018). Moreover, the usage of new technologies will increase the possibility of the port in the future, or Smart Port. Therefore, the port system will go hand in hand with data transmission systems and big data; the implementation of which will allow a complete transformation in many areas.

1.2.1 Green port

The green port concept played a significant influence in recent years. Any modern port should be adapted to models of green and intelligent development by emphasizing on environmental protection and technology aspect. According to Karim (2017) the greenness of each port is based on its characteristic. For the development of an intelligent or smart port both of green and smart port have to be interrelated to each other as one systematic concept which was developed based on systematic governance framework (Chen.,2019).

1.2.2 Sustainable maritime development

Oceans have always been exceptionally important for the purpose of sustainable development in relation to the blue economy. These extremely complex and constantly adaptive natural systems integrate numerous elements including climate and weather, flora and fauna and mineral resources. They remain to be a vital means of transportation, source of food, recreational destination and unique scientific observations and discovery. Moreover, all the elements of this system are united by multiple interactions among them and are interdependent. As a consequence, oceans have been mentioned in all related strategic documents from the Stockholm Declaration, 1972 to the RIO+20 Conference document “Future We Want”, 2012. Sustainability in maritime transport has been an important consideration over the last few years. The significant rise of international trade carried by sea has led to an increase in air emissions and their harmful impacts on human health and environmental change (Christodoulou.,2019). Below are the pioneer Green ports in the world.

Table 1: Pioneer Green Ports in the World

S/N	NAME OF PORT	COUNTRY	TYPE OF GREEN PORT INITIATIVE
1.	Port of Genoa	Italy	Onshore power to ship using renewables
2.	Port of Hamburg	Germany	Onshore power to ship using LNG
3.	Port of Gothenburg	Sweden	Hydrogen production facility (potential for small vessel fuel)
4.	Port of London	England	Hydrogen Highway – National hydrogen highway network to integrate land, sea, and port
5.	Port of Los Angeles	USA	Adoption of Hydrogen based zero emission onshore equipment
6.	Port of Newcastle	Australia	Plans to become a green energy export hub
7.	Dampier and Port Hedland,	Australia	Oceania Marine Energy plans to bring a fleet of the world's first green bunker vessels to service the world's largest fleet of iron ore carriers

Source: Energy Transition (2023)

1.2.3 Policy Framework Components

In Nigeria, laws that relate to environmental management are hinged on the National Environmental Policy, alongside the legislation, benchmark, orders and regulations aimed at preserving natural resources and protecting the health of her citizens. Therefore, the role of key actors in the formulation, ratification and discharge of environmental practices and norms, legislation and regulations are used to assess ecological laws, environmental policy formulation and implementation, public and regional plans and programs development and implementation, establishment and operation of ecological organisations that monitor, execute and supervise all aspects of the system, and the state`s dedication to international environmental treaties and law. These institutions provide the resources for human and technical requirements to carry out environmental plan implementation activities and programs. (David,2022).

Building a green and smart port in Nigeria requires a comprehensive policy framework that addresses environmental sustainability, technological innovation, and economic development. Such a framework should prioritize the adoption of green technologies, digitalization, and efficient port operations to ensure long-term success and competitiveness in the global maritime industry Oko et al., 2022). The development of smart ports has become imperative in the context of rapid

globalization and advancements in technology. A robust policy framework that underpins these ports is essential for ensuring efficiency, sustainability, and security. The components of such a framework can be delineated into five core areas: governance, infrastructure, technology integration, sustainability, and stakeholder engagement (Adewale, 2022).

1.2.4 Government Policy

Effective government policies are imperative for promoting smart port initiatives. The Nigerian government has demonstrated interest in port modernization, as evidenced by the National Transport Policy (2018). This policy encourages investment in smart technologies and infrastructure. However, as Jibunoh (2020) notes, inconsistent policy enforcement and bureaucratic inefficiencies hinder progress. Thus, a stable regulatory framework is essential for attracting investment and guiding the adaptation process. Governance refers to the institutional arrangements that guide decision-making processes within the port ecosystem. Effective governance structures should promote transparency, accountability, and collaboration among various stakeholders, including government agencies, port operators, and logistics companies (Lai et al., 2020).

1.2.5 Infrastructure

Infrastructure plays a pivotal role in the development of smart ports. This includes not only physical assets like berths and warehouses but also digital infrastructure such as cloud systems and IoT networks. Investments in state-of-the-art facilities that facilitate real-time data exchange are vital to enhancing operational efficiency (Notteboom & Vernimmen, 2021).

1.2.6 Technology integration

Where emerging technologies such as AI, blockchain, and big data analytics can significantly optimize port operations. These technologies can address challenges such as cargo tracking, predictive maintenance, and automated customs processes, leading to reduced turnaround times and improved service reliability (Gupta et al., 2019).

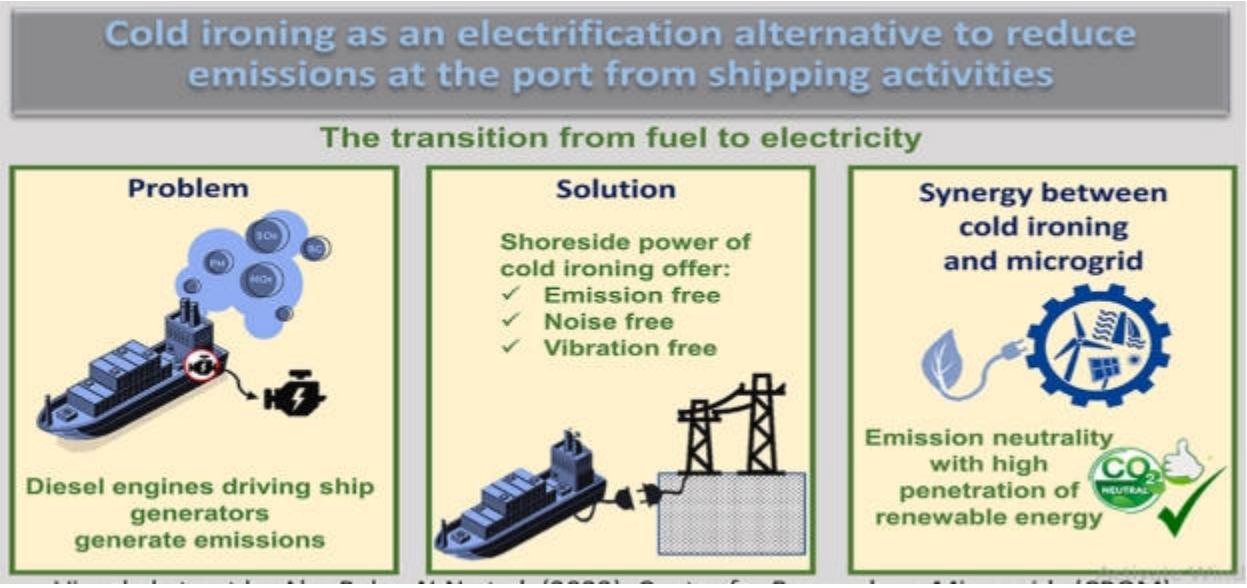


Plate 1: Source: Nur et al. (2023)

1.2.7 A review of the cold ironing technology

Technology innovation further aids in green port development. For instance, the use of electrified berths allows ships to plug into shore power during docking, drastically reducing emissions from docked vessels. It proposes the utilization of a cold ironing framework within the harbor of Barcelona, where the control era is totally provided by renewable energy sources (wind turbines and photovoltaic panels). The thought is to contribute to the widespread adoption of cold ironing within smart ports' micro-grids to realize the objective of zero emissions from berthed ships.

The fourth element, sustainability, encompasses both environmental and economic sustainability practices. Smart ports must align with global sustainability goals by minimizing their carbon footprint, using clean energy, and promoting eco-friendly logistics solutions (Pereira et al., 2021).

1.2.8 Stakeholder Engagement

Lastly, stakeholder engagement is vital. Collaborative efforts between the government, private sector, and port users can help identify specific needs and tailor smart port solutions accordingly. Public-Private Partnerships (PPP) can facilitate investments and improve service delivery, as seen in successful global examples (World Bank, 2019). Stakeholder engagement is essential in crafting

a responsive policy framework. Engaging public and private actors, including local communities and international trade organizations, fosters collaborative innovation and trust, crucial for the successful implementation of smart port initiatives (Norrman et al., 2022).

1.2.9 Regulatory and Management Frameworks for Smart Ports

The advent of smart ports—integrated logistical hubs empowered by digital technologies—presents new opportunities and challenges for maritime trade. Implementing effective regulatory and management frameworks is essential to leverage these benefits while mitigating risks related to cybersecurity, environmental sustainability, and operational inefficiencies. Regulatory frameworks for smart ports focus primarily on compliance with international shipping standards, data security, and environmental regulations. Organizations such as the International Maritime Organization (IMO) and the International Association of Ports and Harbors (IAPH) provide foundational guidelines that smart ports must adhere to. These regulations ensure that the adoption of digital technologies does not compromise safety or security standards. For instance, the International Ship and Port Facility Security Code (ISPS) mandates robust security measures that ports must implement as they integrate digital systems, ensuring cargo integrity and persWarril safety (IMO, 2023). On the management side, the adoption of the Internet of Things (IoT) and big data analytics necessitates a shift towards data-driven decision-making processes. The establishment of a centralized management information system can facilitate real-time tracking of cargo, fleet operations, and environmental monitoring. A comprehensive stakeholder engagement strategy is vital, involving port authorities, shipping companies, and technology providers to create a harmonized operational framework (Scholten et al., 2020). Effective governance structures, such as public-private partnerships, can enhance collaboration and resource sharing between stakeholders, fostering innovation in smart port operations. Additionally, training and capacity-building programs are necessary for persons in Warri to adeptly navigate new technologies, ensuring that human resources align seamlessly with technological advancements (Chio et al., 2021).

2.0 METHODOLOGY

2.1 Data Collection

The sources of data for this study shall be obtained from primary data. The population of this study is 1200, is a combination of port users and vessel captains in Calabar port, which is the study area. A simple random technique was adopted using Taro Yamane to determine the sample size of 300. Spearman's rank correlation coefficient was used to analyze relationships between the variables. Port automation on yard operation in Calabar Seaport of Nigeria, implications for Africa's regional development.

3.0 RESULT AND DISCUSSION

Table 2: A policy framework will help in building a green port in the maritime industry

S/N	Response	Frequency	Percent
1.	SA	135	45
2.	A	120	40
3.	D	38	12.6
4.	SD	7	2.4
TOTAL		300	100

Source: Researchers' field report (2024)

The participants' responses regarding the policy framework will help in building a green port in the maritime industry, which are presented in Table 2. Out of the total study population, 45% strongly agreed with the statement that the policy framework will help in building a green port in the maritime industry, which amounts to 135 respondents. Additionally, 40% of the respondents agreed with this notion. In addition, 38 individuals (12.6%) expressed disagreement with the notion that a policy framework will help in building a green port in the maritime industry, while the remaining 2.4% strongly disagreed with this idea. This suggests that a considerable portion of the entire population agrees with the position on the continuum. This discovery indicates that 85% of the individuals involved in the study within the specified area were included. Furthermore, it

is worth mentioning that only a small 15% of the total population expressed disagreement with the statement that policy framework will help in building a green port in the maritime industry.

Table 3: Correlation between the policy framework in building a green port in the maritime industry.

Correlations				
			Policy framework	Green port
Spearman's rho	Policy framework	Correlation Coefficient	1.000	.631**
		Sig. (2-tailed)	.	.014
		N	300	300
	Green and smart port	Correlation Coefficient	.631**	1.000
		Sig. (2-tailed)	.014	.
		N	300	300

. Correlation is significant at the 0.05 level (2-tailed). Source:** *SPSS Output version 25*

The correlation analysis output in Table 3 presents the association between the Policy framework and Green port. The findings indicate a strong correlation ($r = -0.628$, $p = 0.014$) between the policy framework and green and smart ports. This was evidenced by the statistical significance of the correlation coefficient. It can be inferred from this analysis that an increase in the Policy framework would result in a corresponding improvement of in the Green port.

3.1 Summary

A robust policy framework for building a green seaport in Warri, Nigeria, will encompass environmental assessments, investment in renewable energy, adoption of smart technology and implementation, stakeholder involvement, and community engagement. Lack of a sustainable Green Port policy has impacted our seaport operations in Nigeria. Laws that will provide an enabling environment for green and smart port policy should be enacted.

3.2 Conclusion

Ultimately, this study has conducted an exhaustive examination of pivotal elements influencing Green Port Policy in Nigeria. A comprehensive policy framework for building a green future must integrate energy transition, operational efficiency, sustainable transportation, and community empowerment. Such a holistic approach will not only address current environmental challenges

but also pave the way for a sustainable and resilient future. Building a green port policy is not merely an environmental aspiration but a necessity in the modern maritime industry. By leveraging renewable energy, improving waste management, and integrating innovative technologies, ports can play a crucial role in combating climate change while catering to the ever-increasing demands of global trade. Green Port Policy in Nigeria is not merely an environmental initiative but a comprehensive strategy for economic advancement and global competitiveness. By prioritizing green practices, Nigeria can position its ports as models of sustainable development in Africa, ensuring a balanced approach to maritime growth.

3.3 Recommendations

The rapid evolution of global commerce necessitates the transformation of traditional port operations into sustainable and technologically advanced hubs. Warri Port, positioned strategically along the coast of Nigeria, stands as a pivotal location for implementing a green and smart port initiative to foster both economic growth and environmental stewardship. A comprehensive environmental assessment is crucial. This assessment should evaluate the local ecosystem, focusing on biodiversity, water quality, and air pollution. By understanding these dynamics, stakeholders can implement targeted measures to minimize environmental impact. An investment in renewable energy sources is vital. The port should aspire to utilize solar panels, wind turbines, and alternative fuel technologies, decreasing reliance on fossil fuels. This shift will not only cut carbon emissions but also position Warri port as a leader in sustainable logistics within the region. The development of smart technology is paramount. The integration of IoT (Internet of Things) devices can optimize cargo tracking, enhance logistical efficiency, and provide real-time data analyses to improve decision-making processes. Also, implementing an intelligent traffic management system can reduce congestion, enhancing the port's overall operational efficiency. Furthermore, engaging stakeholders, including government agencies, international organizations, and private sector partners, will ensure a holistic approach to port development. Public-private partnerships can be instrumental in securing funding and expertise for innovative initiatives. Finally, it is essential to foster community involvement and maintain transparency with local populations, ensuring that the benefits of developing a green and smart port reverberate throughout the region.

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