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Benchmarking Analysis for Sustainability Practices of Green Port Initiatives at Northport (Malaysia) Berhad with Other Selected Port in Urban Future Development

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ABSTRACT

Port industries are crucial as the primary transport modes for transportation of goods. Globalisation has transformed trading patterns, making ports the vital hubs in the supply chain. However, ports operation causing significant pollution, contributing to the increasing level of global emissions that necessitates port to decarbonise. Consequently, major ports around the world have started implementing Green Port Initiatives (GPIs) to address these issues. This research aims to benchmark the GPIs at Northport with the chosen international and local ports to ensure the sustainability of its GPIs and align with urban planning objectives, such as reducing pollution and enhancing resilience. The study utilises the SWOT and PESTEL analyses to assess the internal and external factors influencing the sustainability of the GPIs. Data was collected through interviews and reviews of GPIs implemented at Northport and compared to those selected ports. The findings reveal that Northport excels in areas such as GPIs planning, energy efficiency, emissions reduction, and continuous monitoring. Despite high implementation costs, GPIs lead to energy savings and improved its revenues. Moreover, adherence to international standards is critical not only for Northport sustainability but to remain competitive too. Benchmarking against industry standards is vital for continuous improvement and ensuring that port development complements sustainable urban planning frameworks, creating liveable, resilient, and economically vibrant urban area.

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INTRODUCTION

Port significant function mainly due to economic factors, with sea and ocean routes being primary modes of transport. Globalisation and economic changes have transformed trading patterns, making ports crucial hubs in the supply chain, connecting sea, road, rail, and inland cargo (Yin et al., 2023). Song et al. (2021) highlight that vessels are cost-effective for transporting large cargo volumes, reaching remote areas, and supporting economic development by moving essential commodities like oil, coal, and grains. This has strengthened international trade, promoting economic interdependence and cooperation (Young et al., 2023). Nowadays, the ports worldwide are expanding, complicating safety, health, and environmental management. Iris (2019) noted that port operations and growth have negative environmental impacts due to their expansion. Since the early 1980s, environmental issues have been a major concern for port authorities, the maritime industry is said has significantly contributed to global emissions, making port decarbonisation crucial for broader green initiatives. Accidents, oil spills, and water contamination are major environmental issues at sea.

Green Port Initiatives (GPIs) were introduced and involve environmentally sustainable practices to reduce ports' environmental impact and promote responsibility to environment and social community (Molavi et al., 2020). These initiatives aim to minimise air and water pollution, habitat destruction, and energy consumption (Arof et al., 2021). The concept gained traction in the late 20th and early 21st centuries, with significant promotion at the 2009 United Nations Climate Change Conference (Lawer et al. 2019). Currently, ports worldwide have adopted green practices due to regulations, public concerns, and the need for sustainable development. GPIs typically involve cleaner technologies, energy efficiency, waste reduction, and alternative energy sources, balancing economic benefits with environmental requirement (MacNeil, 2021).

Northport, one (1) of the major Malaysian ports, has been recognised for its green initiatives, receiving the APEC Port Services Network (APSN) GREEN PORT 2016 and 2020 award. Benchmarking initiatives with other ports helps Northport to identify improvement areas, stay updated on industry standards, and enhance environmental performance. Without benchmarking, Northport risks inefficiency, regulatory non-compliance, and losing market share to greener ports. Increased emissions and pollutants could harm local communities and marine ecosystems, and the lack of commitment to sustainability might affect stakeholder trust and employee awareness. This study aims to benchmark Northport's GPIs against those of other prominent ports, focusing on their significance to both port sustainability and the broader urban planning efforts in the Port Klang area especially in Bandar Sultan Suleiman.

This benchmarking analysis is not only critical for improving Northport's internal sustainability practices but also has broader implications for urban planning in the surrounding port area. Furthermore, sustainable practices in the port industry contribute to the resilience of coastal cities, mitigating the risks posed by climate change, such as rising sea levels and extreme weather events. A comprehensive benchmarking analysis of Northport's sustainability efforts with those of other global ports will offer valuable insights into how the port can further reduce its environmental footprint. It will also provide urban planners with the information they need to integrate the port into broader sustainable urban development strategies. Therefore, this benchmarking study is not only essential for Northport's operational efficiency and regulatory compliance but also a key driver of urban sustainability in Malaysia.

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LITERATURE REVIEW

The objective of sustainable development in the port industry is to establish benchmarks for sustainability performance, identify opportunities for improvement, and promote research-driven practices (Adegoke, 2018). In the context of ports, sustainability focuses on long-term environmental protection and energy efficiency. The development of sustainable practices is critical not only for preventing environmental degradation but also for enhancing economic performance. In business, sustainability is linked to strategies that address internal and external factors, ensuring the long-term viability of operations while minimising environmental impacts.

Sustainability benchmarking is a systematic method for evaluating the success of standards, certifications, organisations, and businesses that contribute positively to the environment. By identifying key sustainability standards, ports can adopt policies or initiatives from other organisations that have proven successful (Ferrari et al., 2019). As Ferrari points out, benchmarking is a continuous learning process that compares an organisation's practices with those of similar entities. This enables ports to adopt best practices and refine their own strategies for improvement, thus remaining competitive while addressing environmental concerns (Molavi et al., 2020). Benchmarking promotes a culture of innovation, helping ports identify opportunities for sustainable growth.

Global green shipping policies and practices provide valuable examples for the port industry. Lee & Nam (2017) highlight the importance of adopting green technologies in Europe, the United States, Japan, China, and South Korea, emphasising the role of companies like Maersk. Maersk, as a leader in sustainable shipping, introduced advanced ship designs and technologies to reduce pollution and improve operational efficiency. The company also complies with International Maritime Organisation (IMO) standards ahead of schedule, setting an industry benchmark for sustainable practices. As global regulations become stricter, ports and shipping companies must adopt similar green initiatives to remain competitive in maritime trade.

Abdoulkarim et al. (2019) explored the development of dry ports in Europe, applying benchmarking to select high-performing companies in the same sector. They demonstrated that benchmarking, when combined with comparable management processes, allows for the identification of best practices that can be replicated in other locations. By benchmarking dry ports, they were able to differentiate successful initiatives from underperforming ones, creating a roadmap for continuous improvement in port operations.

Northport, a major port in Malaysia, stands to benefit from benchmarking its Green Port Initiatives (GPIs) with other ports that have successfully implemented similar programs. For instance, Long Beach Port, which was recognised as the "Best Green Seaport" in 2018 at the Asian Freight and Supply Chain Award in Shanghai, serves as a benchmark for Northport (Lis, 2021). Long Beach's success can be attributed to its Green Port Policy, which improved air and water quality through initiatives like the Clean Air Action Plan and the Technology Advancement Program (Hossain et al., 2021). Benchmarking Northport's GPIs against Long Beach's initiatives could reveal opportunities for Northport to enhance its environmental performance.

Through this benchmarking process, Northport can identify areas for improvement in its GPIs by examining the best practices of other ports. Benchmarking is a powerful tool that provides several advantages (Gharehgozli et al., 2016). First, it allows ports to analyse more efficient operations, identifying gaps in their sustainability efforts. Second, regular benchmarking enhances overall organisational effectiveness and efficiency, leading to better resource management and reduced environmental impact. Lastly, benchmarking enables ports to stay competitive by adopting innovative strategies that facilitate sustainable growth. By aligning benchmarking efforts with urban planning strategies, Northport can ensure

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that its growth contributes positively to the surrounding urban environment while maintaining its role as a key economic player.

From an urban planning perspective, integrating sustainability benchmarks into port development is crucial for creating liveable, resilient cities. Ports are major contributors to urban economic growth, but they also pose environmental challenges such as air pollution, congestion, and habitat destruction. Benchmarking GPIs allows ports like Northport to adopt best practices from leading sustainable ports, improving environmental performance while addressing urban planning objectives (Lam & Notteboom, 2014). For example, initiatives aimed at reducing carbon emissions, implementing green technologies, and enhancing waste management contribute not only to port sustainability but also to the broader goals of urban planning, such as reducing urban pollution and mitigating climate change. This approach aligns with the growing global emphasis on sustainable urban planning, which seeks to balance economic, environmental, and social goals in city development (UN-Habitat, 2016).

METHODOLOGY AND STUDY AREA

This study employs a qualitative research method, utilising interviews as the primary data collection tool. The interview sessions were conducted with respondents from Northport who are directly responsible for the GPIs. The interview questions focused on the sustainability of the GPIs and analysed the information by thematic analysis, while additional data on these initiatives was obtained from their port official website. The process of benchmarking GPIs at Northport involves several key steps, as shown in Fig 1.

First, it begins with identifying the GPIs already implemented at the selected port. This involves a comprehensive analysis of the port's current sustainability practices, such as energy efficiency, waste management, air and water quality improvement, carbon emissions reduction, and the adoption of green technologies. By identifying these GPIs, a clear understanding of the port’s sustainability efforts and objectives is established.

Next, the identified GPIs from different ports are compared and mapped into the various areas of the Green Port Concept. This step evaluates the similarities and differences in the GPIs implemented by different ports, ensuring alignment with sustainable practices, environmental protection, social responsibility, and economic viability. Mapping the GPIs into the Green Port Concept provides a standardised framework for evaluating the sustainability efforts of different ports, enhancing the benchmarking process's effectiveness.

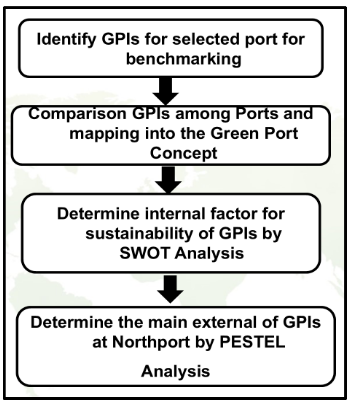

Fig. 1. The Process of Benchmarking

Source: Author (2024)

The SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis provides insights into the factors influencing the sustainability of Green Port Initiatives (GPIs) at Northport. It highlights strengths like environmental management systems, stakeholder engagement, efficient waste management, and renewable energy projects, enabling Northport to further improve its sustainability practices. Weaknesses are also identified, such as challenges in implementation, resource limitations, and gaps in monitoring systems. Recognising these helps Northport strategise to overcome obstacles.

Opportunities like technological advancements, regulatory changes, and potential partnerships can enhance Northport's GPIs. Threats such as environmental risks and regulatory shifts are addressed through proactive planning.

Additionally, a PESTEL (Political, Economic, Social, Technological, Environmental, and Legal) analysis examines external factors affecting GPIs, helping Northport make strategic decisions. By integrating both SWOT and PESTEL analyses, the benchmarking process becomes more comprehensive, covering both internal and external influences. This combined approach, supported by Debnath et al. (2021) and Sanchez et al. (2020), is effective for evaluating sustainability and is useful for integrating GPIs into broader urban planning strategies.

RESULTS AND DISCUSSION

Comparison of GPIs among Ports and Mapping the Green Port Concept

The Green Port Concept, as outlined by Hairul et al. (2020), emphasises six (6) fundamental areas crucial for sustainable port operations: energy consumption, sustainable development, water quality, waste management, air quality, and sustainable business practices. Table 1, 2, 3, and 4 shown GPIs that implement by selected ports were updated until June 2024, so some ongoing or new GPIs might not be reflected.

Table 1. GPIs by Port of Long Beach

No	Initiatives	Green Port Concept Area
1	Clean Air Action Plan development for anti-air pollution planning, including programs to reduce truck and vessel pollution and advanced technologies like hybrid tugboats.	AQ
2	Implementation of shore power supply to reduce emissions by allowing vessels to use landside electricity while at berth.	AQ
3	Clean Trucks Program to reduce pollution from trucks operating in the port area.	WM
4	Real-time air and weather data collection to monitor air quality in the Port of Long Beach.	AQ
5	Water and sediment quality monitoring program in the Port of Long Beach has improved greatly over the last 40 years.	WQ
6	User-friendly rules and regulations for on-water discharges and vessel maintenance within and beyond the port.	SBP
7	Adoption of renewable energy technologies like solar panels and energy storage to enhance resilience during emergencies.	EC
8	Port Community Electric Vehicle Blueprint to promote the use of electric vehicles in the port area.	EC

9	Compliance with the California Environmental Quality Act (CEQA) for considering environmental impacts of development projects.	SBP
10	Addressing climate change risks such as sea level rise, increased precipitation, flooding, extreme heat, and storms at the Port of Long Beach.	SD

Source: Authors (2025)

Table 2. GPIs by Asyaport

No	Initiatives	Green Port Concept Area
1	Asyaport ensures that all port operations adhere to the framework of laws and international regulations.	SBP
2	Marport is the first port in Europe and Turkey to use LNG in its in-port carriers, promoting sustainable development.	SBP
3	Asyaport have the Solar Energy System which produces electricity.	EC
4	The port categorises and stores generated waste separately according to its type, complying with legal requirements.	WM
5	A rainwater collection channel has been laid in the port area to collect the rain falling within the body of Marport.	SD
6	All cranes in Asyaport are powered by electricity to minimise carbon emissions and environmental impact during operations.	AQ
7	The port utilises solar energy panels, LED lighting, and LNG usage, demonstrating concrete steps towards sustainability.	EC
8	Asyaport has implemented measures to prevent soil pollution, including an impermeable concrete floor that contains any potential leakage.	SD
9	Safety Data Sheets (SDS) for all chemicals used in Asyaport are up to date, and storage and usage comply with relevant regulations.	SBP
10	Port of Turkey provides training to its employees on environmental legislation and general environmental awareness.	SD
11	Seawater quality within Asyaport is analysed twice a year from various points and depths, with additional examination conducted by the Ministry of Health.	WQ

Source: Authors (2025)

Table 3. GPIs by JPA

No	Initiatives	Green Port Concept Area
1	Implement the JPA Green Procurement Policy and establish the Energy Audit for JPA headquarters.	SBP
2	Replacement the fluorescent lamps with LED lights.	EC
3	Installed solar panels.	EC
4	The hydrodynamic Simulation project was conducted within the Tanjung Pelepas port limit.	WQ
5	Develop a baseline study to comply with the International Convention on The Control and Management of Ships Ballast Water and Sediment 2014 (BMW 2014) at both ports in Pasir Gudang and Tanjung Pelepas.	WQ
6	Developed a Green Lung via Tanjung Pelepas Ecological Park (TPEP) at PTP.	SD
7	Ship Emission Management System (SEMS) – tabulating of emission levels (for CO2, Sox, NOx, PM2.5, PM10 and HC) from all vessels operating at JPA port limit.	AQ

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8	Studies related to Dugong, Otters and Seahorse habitat within PTP – a collaboration with ALAMI Club.	SD
9	Developed the On-Shore Power Supply (OPS) for JPA boats.	AQ
10	MOU between JPA, Malaysian Industry–Government Group for High Technology (MIGHT) and TNB in conducting the Sustainable Energy Project (SEP) for ports and its tenants.	SBP
11	Photovoltaic solar panels installation.	EC
12	Fixed the air conditioning temperature to 24 degrees Celsius and deduction of 0.5 hours of air conditioning operations daily.	EC
13	3R (Reduce, Reuse, Recycle) bins were placed at all levels.	WM

Source: Authors (2025)

Table 4. GPIs by JPA

No	Initiatives	Green Port Concept Area
1	Northport conducted a "Ayuh kitar semula" programme annually among staff and department to promote the recycle initiatives.	SD
2	Northport implemented Port Reception Facilities (PRF) to efficiently manage ship-generated and land-generated waste and prevent pollution.	WM
3	Northport utilises 13 units of Electrified Rubber Tyred Gantry (eRTG) with eco-friendly shore power supply and reducing carbon emissions.	EC
4	Northport conducted a Landscape Competition to encourage teamwork, creativity, and innovation among employees and increase greenery within the port.	SD
5	Solar panels are being installed at NDSB warehouses and future building developments as a renewable energy initiative.	EC
6	Rainwater Harvesting System with a capacity of approximately 80 gallons is being used for irrigation of the surrounding landscape.	SD
7	Northport provides cold ironing (shore power) facilities for Marine Tugboats at Wharf 8A, reducing emissions.	AQ
8	Ballast water monitoring for vessels by Port Klang Authority (PKA).	WQ
9	Northport conducts effluent wastewater monitoring, including vessel-generated pre-wash/wastewater, complying with environmental regulations.	WQ
10	LED lights have been installed in various facilities, saving energy and being highly efficient compared to incandescent lights.	EC
11	Northport incorporated the environment required in the tender process to ensure the contractors are environmentally compliance.	SBP
12	Northport introduced a new conveyor system for Palm Kernel Expeller (PKE) operation to reduce dust emission from cargo.	AQ
13	Preservation of mangroves at the shoreline as Northport initiative to protect the balance of the ecosystem and its biodiversity.	SD

Source: Authors (2025)

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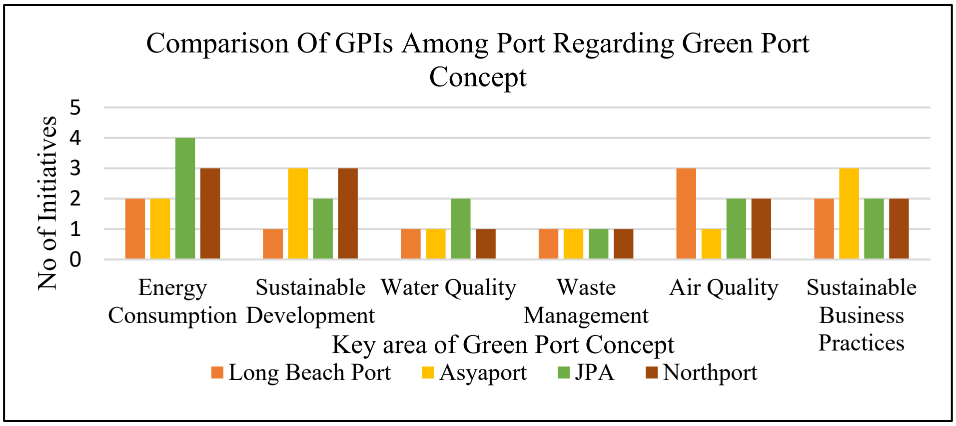

Fig. 6. Comparison of GPIs Among Ports Regarding Green Port Concepts

Sources: Sources: Port of Long Beach (n.d.), Asyaport (n.d.), Johor Port Authority (n.d.), Northport (n.d.).

Fig. 6 shows a comparison of GPIs among selected ports regarding green port concepts. Ports worldwide are increasingly integrating renewable energy technologies to promote energy conservation and efficiency. The selected ports, including the Port of Long Beach, Asyaport, JPA, and Northport, serve as examples of ports that have adopted various green initiatives to support sustainable development.

In the area of energy consumption, the Port of Long Beach has installed solar panels and self-generation systems, enabling it to operate independently from the local grid during emergencies. These systems also stabilise energy costs and enhance grid performance for port tenants. Similarly, Asyaport relies on a 1280-panel solar energy system, significantly reducing its dependence on conventional electricity sources. JPA and Northport are also embracing solar energy, with photovoltaic systems and plans for future installations in warehouses and new buildings.

The focus on sustainable development in the port sector aims to improve environmental performance while maximising long-term economic benefits, the Port of Long Beach has developed a Climate Adaptation and Coastal Resiliency Plan (CRP) to mitigate risks such as sea-level rise and extreme weather. Asyaport has introduced LNG for in-port carriers, reducing reliance on fossil fuels. Additionally, measures like impermeable concrete floors help prevent soil pollution. The JPA's 3R program and Northport's green campaigns emphasise waste reduction and recycling, fostering environmental awareness among employees.

In terms of water quality, all the selected ports are interested in developing strategies for water conservation to enhance water quality and preserve the water supply The Port of Long Beach has improved water and sediment quality through stringent regulations and pollution control. Asyaport harvests rainwater and regularly monitors seawater quality. The JPA adheres to international ballast water management standards and monitors water quality in drainage systems. Northport's rainwater collection system and ballast water initiatives underscore their commitment to preserving water resources.

In waste management, all the selected ports prioritise the prevention and proper disposal of industrial waste, such as lubricant oil, garbage, and other materials that can be harmful to the environment. The Port of Long Beach's Clean Truck Program has drastically cut truck emissions. Asyaport segregates waste and ensures proper disposal through licensed facilities. The JPA has comprehensive waste management plans, and Northport offers Port Reception Facilities for efficient waste handling, highlighting their dedication to minimising environmental impact.

In terms of air quality, all the selected ports are actively working towards reducing gas and air emissions generated by their equipment and machinery. Research conducted by (Joung et al., 2020) aligns with the International Maritime Organisation's (IMO) target to reduce carbon emissions by at least 70% by 2050, with a target of 50% set in 2008. The Port of Long Beach's Clean Air Action Plan includes strategies like the Clean Trucks Program and hybrid tugboats. Asyaport operates cranes electrically and uses LNG for internal transport. The JPA's Ship Emission Management System (SEMS) monitors emissions, while Northport's Electrified Rubber Tyred Gantry significantly reduces carbon emissions. These initiatives collectively enhance air quality around the ports.

In the area of sustainable business practices, all ports have a responsibility to consider the environment, economics, and social concerns in their decision-making processes. The Port of Long Beach collaborates with educational institutions through The Long Beach College Promise, while Asyaport ensures compliance with legal and international standards. The JPA's ecological studies and Northport's mangrove preservation program demonstrate their commitment to biodiversity and environmental preservation.

Northport has demonstrated a strong commitment to sustainability through its implementation of various GPIs, which have significant implications for urban benefit. By integrating renewable energy sources like photovoltaic systems, Northport not only reduces its reliance on conventional electricity but also aligns with urban energy efficiency goals, contributing to a more sustainable urban energy grid. The port's advanced waste management practices, such as the establishment of Port Reception Facilities, ensure that industrial waste is handled responsibly, thereby preventing environmental degradation and protecting the surrounding urban environment.

Northport's initiatives to improve water quality, including rainwater collection systems and ballast water management, play a crucial role in preserving essential water resources. These measures support urban resilience by safeguarding water quality, which is vital for both the environment and public health. The adoption of the Electrified Rubber Tyred Gantry at Northport significantly reduces carbon emissions, directly enhancing air quality and benefiting the health of urban communities near the port.

Moreover, Northport's commitment to sustainable business practices, exemplified by its mangrove preservation program, highlights its role in supporting biodiversity and strengthening urban ecological networks. These initiatives not only contribute to a safer and healthier environment but also promote a harmonious balance between industrial activities and urban living. By embedding these GPIs into its operations, Northport not only sets a high standard for port sustainability but also plays a critical role in advancing sustainable urban development, improving the quality of life for residents, and supporting economic growth in the region.

SWOT And PESTEL Analysis

To identify the factors influencing the benchmarking of GPIs at Northport, both SWOT and PESTEL analyses were employed. The SWOT analysis was chosen to examine internal factors encompassing strengths, weaknesses, opportunities, and threats, given its widespread use as a strategic planning tool.

Table 5 shows that SWOT analysis enables an assessment of the internal strengths and weaknesses related to the implementation of GPIs.

Table 5. SWOT Analysis

Strength	Weakness
GPIs Plan and Clear GPIs Objectives	Cost of GPIs Implementation
Reduction of Energy Consumption	
Identification of GPIs Efficiency Measures	
Top Management Involvement	
Continuous Training of Staff	
Continuous Monitoring for Sustainability	
Opportunity	**Threat**
Reduction of energy costs and improvement of revenue.	Follow the international and national standard policies.

Source: Authors (2025)

In terms of strengths, Northport has developed a detailed GPIs plan that encompasses various initiatives regarding to the port's unique characteristics, activities, and energy needs. Northport places a high emphasis on improving energy performance, reducing energy consumption, and minimising air emissions as key factors in implementing GPIs. All these factors are carried over from their established GPIs. The measurement of GPIs' progress is based on energy efficiency in port operations. Moreover, the implementation of GPIs at Northport leads to a reduction in air emissions, thereby minimising the negative impact of port operations on human health and climate change (Azarkamand et al., 2020).

Northport conducts assessments of efficiency measures for GPIs based on various criteria, which includes the implementation of a monitoring plan to track and evaluate progress. Northport ensures continuous monitoring of GPIs and maintains progress reports. This ensures traceability and allows for the review of sustainability efforts by port management to foster ongoing improvement. The structured framework of GPIs requirements aids in monitoring and accurately measuring the performance of newly introduced technologies. This framework can also stimulate the development of innovative technologies that further enhance sustainability practices at the port (Tang et al., 2022).

This analysis recognises the significance of active involvement by top management and the necessity for a clear policy to enhance the sustainability of GPIs. Management's engagement with the port community serves to promote and drive the sustainability of GPIs. Additionally, Northport emphasises the importance of providing continuous training for staff regarding GPIs. Research has shown that inadequate training and insufficient staff involvement can be significant issues; therefore, continuous training enhances the successful implementation and sustainability of GPIs (Bhatia & Jakhar, 2021).

In addition, the cost of implementing GPIs should be considered in terms of its impact on operational costs. Northport acknowledges that the cost of implementing GPIs poses a significant barrier and challenge to their successful execution (Williamsson et al., 2022). However, this barrier can be overcome through the implementation of GPIs, which leads to reduced energy usage, resulting in cost savings for meeting the port's energy needs. Consequently, GPIs contribute to improved port revenue and offset the costs associated with their implementation.

Adhering to international and national standard policies is a fundamental aspect of sustainability practices within GPIs. These policies serve as a set of guidelines and regulations established to ensure safety, quality, compliance, and consistency across various domains. International and national standard policies often encompass safety regulations designed to safeguard individuals, communities, and the environment. Northport diligently adheres to international and national standards and policies, such as those set forth by the International Maritime Organisation (IMO), aligning them with the requirements of GPIs (Humphries et al., 2022). Non-compliance with these regulations can lead to legal consequences, fines, or even the potential closure of business operations. Thus, it becomes a significant threat to Northport if they fail to adhere to international and national standards.

Northport's commitment to sustainability through GPIs not only enhances its operational efficiency but also contributes to urban planning by improving air quality, promoting energy conservation, and ensuring environmental compliance. These efforts help create a safer, healthier environment for both the port and the urban communities it serves. However, the financial aspects of implementing such initiatives must be carefully managed to ensure long-term sustainability and alignment with urban development goals. The findings suggest that Northport's approach to GPIs can serve as a model for integrating sustainable practices into urban planning, contributing to a more resilient and sustainable urban environment. The external factors identified as influencing the adoption of GPIs have been categorised into the PESTEL framework.

Based on research conducted by Fosher (2018), all external factors have been classified into six (6) PESTEL categories: political, economic, social, technological, legal, and environmental. This classification aims to enhance our understanding of the marketing and management of green port initiatives. Table 2 presents external factors that impact the sustainability of GPIs, along with the respective categories to which they belong.

Table 6. External Factor Influencing the Sustainability Practices of GPIs

PESTEL	External Factors
Political	Introduction of new regulation or policies for GPIs
Economic	Competitive benefit (Commitment to sustainable development)
Social	Integration of GPIs in the port's activities
Technological	Development of new technologies for equipment at port
Environmental	Decreasing impact of air pollutants on human health and climate change
Legal	Targeting future initiatives related world regulations

Source: Authors (2025)

The political landscape plays a crucial role in shaping sustainability practices for GPIs. Government policies and regulations significantly impact how GPIs operate. For instance, stringent emissions standards and mandates for renewable energy use can drive ports to adopt more sustainable practices (Chang et al., 2023). The International Maritime Organisation (IMO) has set ambitious goals to reduce carbon emissions in shipping, aiming for a 40% reduction by 2030 and a 50% reduction by 2050 compared to 2008 levels. For Northport, staying informed about such regulations is vital to maintain compliance and advance its sustainability goals.

Economically, embracing sustainable development offers ports competitive benefits. By committing to eco-friendly practices, Northport can attract business from markets that prioritise environmental responsibility. Sustainable practices like efficient resource management enhance the port's resilience against environmental challenges, securing long-term economic stability (Kabashkin, 2023). This commitment to sustainability can open new business opportunities and partnerships, both domestically and internationally.

Social factors also play a significant role in the success of GPIs. Public opinion, community attitudes, and societal values influence port operations and necessitating urban planning that supports these socio-economic developments through housing, transportation, and public services. Increased public awareness and support for environmental conservation can enhance a port’s reputation and foster community engagement (Katuwawala & Bandara, 2022). Integrating GPIs into Northport’s activities can create jobs, develop local skills, and improve the quality of life for nearby residents, strengthening community relations.

Technological advancements are essential for monitoring and improving GPIs. Innovative technologies can significantly enhance the environmental sustainability and efficiency of port operations. For instance, advanced cargo-handling machinery, automated systems, and optimised logistics software can reduce energy consumption and emissions (Othman et al., 2022). Implementing intelligent infrastructure, such as traffic management systems and real-time environmental monitoring, further supports sustainability and safety.

From an environmental perspective, GPIs aim to reduce air pollutants that harm human health and contribute to climate change. Emissions from port activities, including particulate matter, sulfur dioxide, and nitrogen oxides, pose serious health risks. GPIs strive to minimise these emissions to protect the health of local communities (Caliskan, 2022). Investing in research and development for innovative technologies and practices can further mitigate environmental impacts, demonstrating a long-term commitment to sustainability.

Legally, green ports must stay proactive in understanding and complying with international regulations. Monitoring global maritime regulations, such as those from the IMO, ensures that ports meet legal standards and reduce their environmental footprint (Mao & Shang, 2023). Trade agreements often include environmental clauses that impact port operations, so understanding these legal aspects helps ports like Northport align with global standards and lead in sustainable practices (Othman et al., 2022).

By examining political, economic, social, technological, environmental, and legal factors, Northport can effectively benchmark the GPIs. This comprehensive evaluation helps identify strengths and areas for improvement, ensuring that Northport’s initiatives align with or exceed industry standards. Benchmarking enables Northport to measure its performance, enhance its sustainability achievements, and continually improve its operations as a green port. Moreover, Northport's commitment to sustainability benefits urban planning by fostering eco-friendly development and reducing environmental impacts. Through reduced emissions and innovative technologies, Northport contributes to improved air quality and healthier living conditions in nearby urban areas. Its integration of GPIs also creates job opportunities, stimulates local economies, and enhances infrastructure, supporting urban planners in building sustainable, resilient cities. By aligning port sustainability with urban development, Northport plays a key role in shaping a greener and more sustainable urban future.

CONCLUSION

When comparing Northport's GPIs with local and international ports, it becomes evident that Northport has effectively benchmarked its efforts in alignment with the Green Port Concept. While all ports share the common goal of GPI sustainability, the implementation differs based on geographical factors. Through SWOT and PESTEL analysis, it is clear that Northport excels in key areas such as GPI objectives, port community support, achievement recognition in sustainability, and monitoring plans. Benchmarking these initiatives is crucial for adherence to guidelines, the implementation of effective monitoring systems, top management commitment, continuous training, and financial support. Importantly, by benchmarking its

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GPIs, Northport not only enhances its sustainability but also positively influences urban planning. The reduction of operational costs and environmental impacts through sustainable practices improves urban air quality and supports eco-friendly urban growth. Northport's efforts in sustainability serve as a benchmark for other ports and contribute to creating resilient urban infrastructure, fostering a greener, more sustainable future for the entire region.

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted without any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Iznoorhakmal carried out the research and wrote and revised the article. Siti Ayu provided the method and revised the article. Siti Ayu and Abdul Rauf anchored the review, revisions and approved the article submission.

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