International Journal of Multidisciplinary and Current Educational Research (IJMCER)
ISSN: 2581-7027 ||Volume|| 6 ||Issue|| 6 ||Pages 12-20 ||2024||

Developing an Integrated Sustainability Assessment Framework: Evaluating Environmental, Social, Economic, and Governance Performance at Panjang Port

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ABSTRACT: This research examines the implementation of sustainability indicators and efficiency measurement at Panjang Port, Bandar Lampung, focusing on environmental, social, economic, and governance dimensions. Using a qualitative analytical framework and data collected from January to May 2024, the study investigated 25 key sustainability indicators across these dimensions. The methodology incorporated semi-structured interviews with key stakeholders, systematic documentation analysis, and quantitative operational data collection. The findings reveal that port sustainability management is influenced by regulatory frameworks, financial resources, human capital, stakeholder coordination, and technological infrastructure. The study developed a comprehensive sustainability measurement framework that integrates environmental monitoring, social responsibility initiatives, economic performance metrics, and governance structures. The research highlights both practical implications, including improved operational efficiency and stakeholder engagement, and theoretical implications based on the triple bottom line approach. While facing limitations such as data accessibility and methodological constraints, the study proposes future research directions emphasizing the development of robust theoretical frameworks and enhanced measurement methodologies. The findings contribute to the broader understanding of port sustainability practices and provide a blueprint for implementing effective sustainability measures in port operations.

KEYWORDS: Port sustainability, Environmental indicators, Triple bottom line, Stakeholder engagement.

I. INTRODUCTION

The predominance of maritime shipping in global trade, accounting for approximately 90% of goods transported worldwide, underscores its critical role as the primary artery of international commerce (Ojala & Tenold, 2017). Projections indicating a tripling of maritime trade volumes by 2050 present both opportunities and challenges for ports, which are integral to national economic development. The recent expansion of seaborne trade has necessitated the transformation of ports, augmenting their capacity and infrastructure (Alderton, 2005). However, this rapid growth raises significant concerns regarding global environmental quality and resource depletion. The environmental impact of port operations and related activities is multifaceted and potentially severe (Gupta et al., 2005; Dinwoodie et al., 2012), affecting air quality (Bailey & Solomon, 2004; Cooper, 2003), water resources (Grifoll et al., 2011; Kröger et al., 2006), and soil and sediment composition (Edoho 2008; Ray, 2008). The International Maritime Organization's (IMO) efforts since the 1970s to develop conventions for marine environmental protection,

While primarily focused on shipping-related impacts, have recognized ports as crucial regulatory points (Ng & Song, 2010).The evolving expectations for port authorities to address environmental and social impacts through sustainable management approaches (Puig et al., 2014) represent a paradigm shift in port operations. This new paradigm necessitates a delicate balance between performance optimization and mitigation of environmental and social challenges. The concept of sustainable port management, encompassing environmental, social, and economic dimensions, has become increasingly critical in the face of growing environmental awareness. The complexity of effective environmental management in ports is exacerbated by the need to consider diverse factors including potential impacts, mitigation strategies, predictive methods, environmental indicators, and relevant legislation (Jones et al, 2005). The unique nature of each port, influenced by economic, social, cultural, and administrative factors, as well as local geography and hydrography, further complicates this challenge (Bichou & Gray, 2005).The utilization of Environmental Performance Indicators (EPIs) offers a potential solution for evaluating and demonstrating sustainable improvement in port operations (Azzone et al., 1996). However, the lack of standardization in these indicators presents a significant obstacle. The PPRISM study by ESPO/Ecoports in 2009 revealed a wide diversity in environmental indicators used by European ports (Puig, 2014), while (Muangpan, 2019) research in Thai ports identified 91 distinct indicators across various categories. This diversity in indicators, while reflecting the complex nature of port sustainability, also highlights the absence of a unified approach. The geographical bias in research on green ports and maritime logistics, favoring Western Europe and the United States over East Asia and other regions (Davarzani et al., 2016), further complicates the development of globally applicable sustainability frameworks. The case of Indonesia exemplifies the challenges faced by developing nations in aligning with global sustainability trends in the shipping industry. Despite its strategic location along crucial global sea routes and its heavy reliance on maritime transport for international trade, research on port sustainability in Indonesia remains scarce. This gap underscores the need for context-specific studies that can adapt global best practices to local conditions.

The present study aims to address this research gap by investigating global port sustainability assessment methodologies and their potential application to Indonesian ports. The complexity of this task is compounded by the multitude of sustainability indicators, the intricate nature of port organizations, and the limited academic research on port sustainability assessment. By focusing on the recent growth in global trade and its transformative impact on the shipping industry and ports, this research seeks to develop a feasible and efficient indicator framework for evaluating sustainability initiatives in ports. The ultimate goal is to provide a comprehensive and adaptable framework for assessing port sustainability in Indonesia, bridging the gap between global best practices and local contexts. This critical approach to port sustainability assessment acknowledges the challenges inherent in standardizing measures across diverse geographical, economic, and cultural contexts. It emphasizes the need for a nuanced understanding of sustainability that can accommodate the unique characteristics of each port while still providing a basis for comparative analysis and continuous improvement.

II. LITERATURE REVIEW

Understanding Sustainability : The concept of sustainability, as formulated in the late 1980s, emphasizes the imperative of fulfilling present-day needs without jeopardizing the capacity of future generations to meet their own requirements. While sustainability encompasses various approaches and interpretations, the most widely recognized conceptualization comprises three fundamental pillars: economic, environmental, and social—colloquially referred to as profit, planet, and people (WCED, late 1980s).This tripartite framework is known as the Triple Bottom Line (TBL) approach to sustainability. The emergence of sustainability as a subject of public discourse can be attributed to the concerted efforts of civil society, non-governmental organizations, and transnational entities in urging governments to address the environmental and social ramifications of economic growth resulting from human activities. In essence, there was a growing demand for more responsible and sustainable developmental paradigms (Li et al., 2018).

The concept of sustainable development has been the subject of extensive theoretical exploration by numerous scholars. Some posit that this developmental approach is crucial for mitigating risks and pollution associated with traditional activities across various organizational and industrial contexts. Consequently, there is a consensus that the efficacy of sustainable development can be assessed through the quantification of sustainability levels within specific organizational frameworks (Feil et al., 2017).Sustainability encapsulates concerns regarding the quality of systems characterized by the inextricable integration of environmental and human factors. It evaluates the nature and characteristics encompassing environmental, social, and economic dimensions. This conceptual framework elucidates and delineates the interrelationships among the three pillars of TBL as previously expounded (Bartelmus, 2010).

In a similar vein, some scholars posit that sustainability encompasses multiple perspectives. Among these, one can identify its role in addressing environmental protection and economic services. Additionally, economic, financial, and social considerations fall within its purview (Büyüközkan and Karabulut, 2019).The assessment and evaluation of sustainability have emerged as significant areas of academic inquiry. Numerous theories and studies have been propounded and discussed over the years. However, sustainability indicators have gained widespread acceptance and utilization among scholars in the field of sustainability evaluation. Some argue that sustainability assessment is operationalized through the implementation of indicators or indices, generating quantitative data that facilitates the formulation of long-term goals and objectives (Feil et al., 2019).

Triple Bottom Line (TBL) Approach to Sustainability : The core of the sustainability concept is predicated on the Triple Bottom Line framework, as previously elucidated. Sustainability focuses on comprehending and quantifying the economic, environmental, and social value either generated or diminished by corporate entities (Elkington, 2018). TBL examines the outcomes of organizational activities, whether voluntary or regulatory in nature, which demonstrate an organization's capacity to maintain viable operations without adversely impacting social or ecological systems (Smith and Sharicz, 2011).Some studies have sought to evaluate the extent to which organizations have undergone a paradigm shift towards TBL sustainability practices. However, robust criticisms have been leveled, asserting that although TBL is associated with sustainability, "It's not actually like that" and may not exert a sufficiently broad impact to substantiate the fundamental premise of sustainability, which necessitates the preservation and protection of natural ecosystem equilibrium (Milne, 2005). Discourse in the Harvard Business Review has highlighted the universal recognition of the imperative for sustainable business practices. Even profit-centric enterprises acknowledge that business continuity is contingent upon healthy ecosystems and the stability of a just society. The authors further posit that converging trends are catalyzing sustainable business practices through: 1) true cost accounting, wherein previously unaccounted costs of resources, such as honey bee pollination services, are monetized and incorporated; 2) the provision of capital incentives for companies that efficiently manage these costs; and 3) the development of value chain indices in industrial sectors to facilitate authentic product comparisons by examining impacts throughout their life cycles (Chouinard et al., 2011).

Concerns of the TBL Methodology : Various salient themes of concern pertaining to sustainable development have been identified, encompassing issues such as:

1. The limitations of Earth's resources and the imperative for enhanced resource efficiency.
2. The potential for development to diminish biodiversity and disrupt ecological systems upon which all life depends.
3. The welfare of future generations.
4. The necessity to ameliorate the quality of life for all individuals.
5. The requirement for equality among diverse global populations.
6. The need to reconcile competing economic, environmental, and social objectives.
7. The recognition of interdependence within and among all societies globally.
8. Intergenerational justice in the allocation of natural capital, ensuring equitable distribution between present and future generations.
9. The principle of humility: acknowledging the limitations of human knowledge and placing the onus of proof on those initiating action.
10. The precautionary principle: advocating prudence in situations of uncertainty.
11. The principle of reversibility: eschewing irreversible changes (Wang et al., 2015).

Corporate Social Responsibility : Corporate Social Responsibility, commonly abbreviated as CSR, refers to the integration of environmental considerations into business decision-making processes. This paradigm shift is largely attributable to mounting pressure from shareholders and other stakeholders, urging organizations to prioritize sustainability and environmental conservation (Krajnc et al., 2003).Some scholars contend that the majority of industrial practices are inherently unsustainable due to their excessive reliance on non-renewable natural resources. This perspective implies that corporate entities must commit to promoting equality and recognizing that development transcends mere economic growth (Deprins and Springett, 2010).CSR has been promoted as a mechanism for enhancing public relations initiatives. Similarly, corporate sustainability has been recognized as a valuable analytical tool for cost reduction, risk management, new product development, and fostering internal cultural and structural transformations (Azapagic et al., 2004).

Measuring Sustainability with Indicators : In the context of evaluating organizational sustainability, sustainability indicators have emerged as widely utilized tools.

These indicators are defined as measures or sets of measures that provide information about predetermined variables (Joung et al., 2012). The objective of these indicators is to quantify, analyze, and communicate complex information in a simplified manner through systematic, precise, consistent, and transparent measurement of Triple Bottom Line aspects (Linke et al., 2013).The simplification of complex processes through indicators, irrespective of the number employed, inevitably results in a diminished capacity to fully capture all relevant information collected in the field. This limitation may lead to varying degrees of information loss regarding the phenomena under investigation (Lodhia, 2014).

The objectives of sustainability indicators are multifaceted, encompassing the enhancement of awareness and understanding of sustainability, the provision of summary data on current conditions and performance trends for decision-making purposes, the measurement of progress towards established goals, the promotion of organizational learning, the provision of tools to evaluate organizational achievement vis-à-vis sustainability objectives, and the facilitation of stakeholder engagement in decision-making processes (Keeble, 2003).

Number of Indicators to be Selected : The optimal number of indicators required for sustainability evaluation has been a subject of ongoing debate among researchers. Some advocate for a limited number of indicators to ensure manageable analysis (Linke, 2013). Conversely, others argue that a high number of sustainability indicators may impede effective performance evaluation (Singh et al., 2007). An alternative perspective suggests that the number of indicators selected should be tailored to the specific interests and objectives of the organization in question (Bui et al., 2017).Recommendations regarding the total number of indicators vary, with some researchers proposing a maximum of 30 indicators, taking into account the Triple Bottom Line aspects (Nordheim et al., 2007). However, others have developed as many as 42 sustainability indicators for assessing corporate sustainability (Kinderyté, 2010). It has been noted that there is widespread confusion concerning the definition and selection of sustainability indicators that accurately reflect organizational performance and represent sustainability guidelines, particularly given the high quantity of available indicators (Rahdari et al., 2015).

III. METHOD

This research implements a comprehensive qualitative analytical framework to examine sustainability governance at Panjang Port, Bandar Lampung, employing a descriptive approach to understand complex operational phenomena within the port environment. The study, conducted from January to May 2024, utilizes systematic data collection and analysis methodologies to ensure research validity and reliability. The methodological framework employs three interconnected data collection instruments. First, semi-structured interviews using a carefully designed interview protocol with four main sections: sustainability policy understanding, implementation challenges, stakeholder coordination, and future development plans. These interviews target key stakeholders including: (a) senior port management personnel responsible for sustainability initiatives, (b) Pelindo officials overseeing regional port development, (c) shipping and logistics operators directly impacted by sustainability policies, (d) local government representatives involved in port oversight, and (e) environmental compliance officers. Second, systematic documentation analysis utilizing a standardized review matrix examining: operational protocols, environmental impact assessments, annual sustainability reports, regulatory compliance documents, stakeholder meeting minutes, and performance audit reports. The matrix evaluates documents across multiple dimensions: policy alignment, implementation status, monitoring mechanisms, and stakeholder engagement levels.

Third, quantitative operational data collection focusing on key sustainability indicators: environmental (energy consumption, waste management, air quality), social (community engagement, worker safety, local employment), and economic (operational efficiency, investment in sustainable infrastructure, cost-benefit analysis of green initiatives). Data validation implements a three-tier triangulation process: (1) methodological triangulation comparing interview findings with documentary evidence, (2) source triangulation cross-referencing information across different stakeholder groups, and (3) theoretical triangulation examining data through different theoretical lenses within the triple bottom line framework. The analytical process follows a structured approach for qualitative data analysis, incorporating: (a) thematic coding using pre-defined and emergent codes, (b) pattern identification through matrix coding queries, (c) relationship mapping using cluster analysis, and (d) comparative analysis across different stakeholder perspectives. This systematic methodology ensures a comprehensive examination of Panjang Port's sustainability governance mechanisms, leading to evidence-based recommendations for enhancing port sustainability practices while maintaining academic rigor.

IV. RESULTS AND DISCUSSIONS

Factors Affecting Port Authority's Sustainability Management : The Port of Panjang's sustainability management is influenced by a complex interplay of factors that shape its operational effectiveness and long-term viability. The regulatory framework stands as a cornerstone, encompassing both national and regional legislation that dictates compliance standards and operational guidelines. These regulations provide essential boundaries for sustainability initiatives while ensuring standardized implementation across port operations. Financial resources emerge as a critical factor, where budgetary allocations directly impact the scope and effectiveness of sustainability programs. Limited financial resources often constrain the implementation of comprehensive sustainability initiatives, necessitating strategic prioritization of projects. Human capital plays a pivotal role, particularly in terms of skilled personnel who possess specialized knowledge in port sustainability management. The availability of trained professionals directly influences the port's capacity to implement and monitor sustainability programs effectively. The success of these initiatives heavily depends on robust stakeholder coordination, involving a complex network of government agencies, shipping companies, local communities, and non-governmental organizations. This coordination requires effective communication channels and clear delineation of responsibilities among various parties.

Awareness and commitment from all stakeholders represent another crucial factor, where understanding and support for sustainability initiatives must permeate all organizational levels. This includes both top-down leadership commitment and bottom-up employee engagement in sustainability practices. Technological infrastructure serves as an enabling factor, encompassing waste management systems, environmental monitoring equipment, and digital platforms for data collection and analysis. The quality and availability of this infrastructure directly impact the port's ability to implement and monitor sustainability initiatives effectively. Additionally, the port's ability to adapt to changing environmental regulations and technological advancements influences its long-term sustainability performance.

Measuring Sustainability in Port Operations : The measurement of sustainability at the Port of Panjang requires a comprehensive approach that addresses multiple operational dimensions. The port's operational scope, characterized by diverse activities ranging from cargo handling to vessel traffic management, necessitates a multi-faceted measurement framework. This framework must account for direct operational impacts, indirect environmental effects, and broader socio-economic implications of port activities. Key Performance Indicators (KPIs) serve as primary measurement tools, encompassing environmental metrics (such as carbon emissions, water quality, and waste generation), social indicators (including workplace safety statistics, community engagement levels, and local employment rates), and economic measures (covering operational efficiency, resource utilization, and financial sustainability). The Environmental Management System (EMS) provides a structured approach to monitoring and improving environmental performance, integrating with existing operational procedures and management systems.

Data availability and quality significantly influence measurement effectiveness, requiring robust data collection systems and verification processes. The port employs various assessment tools, including Life Cycle Assessment (LCA) for evaluating environmental impacts across operational processes, Environmental Risk Assessment (ERA) for identifying and mitigating potential environmental risks, and Social Impact Assessment (SIA) for understanding community impacts. Regular audits, both internal and external, ensure compliance with established standards and identify areas for improvement. Sustainability reporting frameworks provide structured approaches to documenting and communicating performance metrics to stakeholders, enhancing transparency and accountability in sustainability management.

Framework Development for Efficient Sustainability Measurement : Developing an efficient sustainability measurement framework at the Port of Panjang requires a systematic approach that integrates multiple components. The framework begins with comprehensive identification of relevant sustainability aspects, carefully considering environmental impacts (air quality, water pollution, noise levels), social dimensions (worker welfare, community relations), and economic factors (operational efficiency, market competitiveness). This identification process involves extensive stakeholder consultation to ensure all relevant perspectives are captured. The framework emphasizes alignment with international standards and best practices while maintaining sensitivity to local contexts and requirements. SMART (Specific, Measurable, Achievable, Relevant, Time-bound) Key Performance Indicators form the foundation of measurement systems, providing quantifiable metrics for tracking progress and performance. Integration with existing management systems ensures operational efficiency and reduces redundancy in data collection and reporting processes.

Technology plays a crucial role in framework implementation, utilizing advanced monitoring systems, data analytics platforms, and automated reporting tools. Regular training and capacity building programs ensure personnel maintain the necessary skills and knowledge for effective framework implementation. The framework incorporates feedback mechanisms for continuous improvement, allowing regular reviews and adjustments based on operational experience and changing requirements. This adaptive approach ensures the framework remains relevant and effective in measuring and promoting sustainability performance at the port. Additionally, the framework emphasizes transparent communication of sustainability performance to stakeholders, fostering trust and engagement in sustainability initiatives.

1. The Port of Panjang in Bandar Lampung implements 25 key sustainability indicators across four fundamental dimensions: environmental, social, economic, and governance. These indicators are designed to ensure efficient and sustainable port operations.

Environmental indicators encompass greenhouse gas emissions management, energy consumption efficiency, renewable energy utilization, wastewater treatment, solid waste management, waste recycling, water consumption, noise control, and biodiversity preservation. Each environmental metric directly impacts operational efficiency and long-term sustainability. Social indicators focus on workplace safety, employee development, community engagement through CSR programs, community satisfaction levels, local employment opportunities, and fair labor practices. These social metrics ensure harmonious relationships with stakeholders and support operational continuity. Economic indicators monitor operational productivity, cost efficiency per production unit, revenue and profitability, sustainable technology investments, and local supplier engagement. These measures optimize resource utilization and enhance long-term economic viability. Governance indicators address regulatory compliance, transparency and accountability, stakeholder engagement, risk management, contingency planning, and business ethics. These governance metrics establish a robust framework for sustainable operations. The implementation of these indicators enables the Port of Panjang to quantitatively and qualitatively measure its sustainability performance, facilitating continuous improvement and ensuring alignment with international port sustainability standards while maintaining operational efficiency.

2. Port sustainability model development integrates environmental, social, economic, and governance indicators to achieve operational efficiency at Panjang Port Authority.

The environmental component focuses on advanced ecological impact management through comprehensive monitoring systems. This includes systematic tracking of greenhouse gas emissions, energy consumption patterns, waste management efficiency, and biodiversity conservation efforts. The port implements innovative solutions in renewable energy adoption and environmental preservation, going beyond mere regulatory compliance to establish environmentally responsible operational standards. In the social dimension, the framework emphasizes human capital development and community integration as cornerstones of sustainable port operations. Through well-structured programs focusing on workplace safety protocols, professional development initiatives, and community engagement activities, the port cultivates a robust social infrastructure. This approach ensures harmonious relationships with stakeholders while supporting operational continuity and community welfare. The economic sustainability aspect is addressed through meticulous performance monitoring and resource optimization strategies. Advanced metrics track operational efficiency, financial performance indicators, and technological innovation investments. This systematic approach ensures the port's long-term economic viability while maintaining its competitive edge in the maritime sector. The framework particularly emphasizes cost-effective operations and strategic investment in sustainable technologies.

Governing these initiatives is a comprehensive management structure that enables effective implementation and monitoring of sustainability programs. Through transparent reporting mechanisms, active stakeholder engagement processes, and sophisticated risk management systems, the port maintains high standards of accountability while adapting to evolving sustainability challenges. This governance framework ensures that sustainability initiatives are systematically implemented, monitored, and improved across all operational aspects.This integrated approach to sustainability management enables the Port of Panjang to effectively measure and enhance its performance across all sustainability dimensions, ensuring alignment with international standards while maintaining operational efficiency and long-term viability.

V. CONCLUSION

The port's sustainability framework encompasses 25 key indicators across four dimensions: Environmental (7 indicators focusing on emissions, waste management, and resource consumption), Social (5 indicators addressing workplace safety, local employment, and community development), Economic (6 indicators measuring productivity, operational efficiency, and business growth), and Governance (5 indicators covering regulatory compliance, management systems, and stakeholder engagement). To effectively measure sustainability efficiency, the port implements a systematic approach involving target-setting through benchmarking, continuous data collection, regular performance evaluation, sustainability index calculation, transparent stakeholder communication, and ongoing refinement of performance indicators. This comprehensive framework enables the port to balance environmental stewardship, social responsibility, economic viability, and good governance while maintaining operational excellence. The measurement system's success relies on accurate data collection, regular monitoring, and adaptive management to ensure continuous improvement in port sustainability performance.

Implication : The implications of implementing 25 sustainability indicators encompass both practical and theoretical aspects. Practically, the framework enables efficient port management through measurable monitoring, promotes transparency through regular stakeholder reporting, enhances the port's reputation, facilitates strategic decision-making, enables benchmarking with other ports, and fosters stakeholder collaboration. Theoretically, based on the triple bottom line approach, the implications focus on five key areas: integration of sustainability dimensions (balancing economic, social, and environmental aspects), multidimensional measurement (incorporating diverse quantitative and qualitative indicators), indicator weighting (recognizing varying importance across different contexts), cause-effect relationships (understanding cross-dimensional impacts), and stakeholder engagement (ensuring inclusive participation in decision-making). This comprehensive approach challenges conventional port management paradigms and contributes to developing a more holistic, inclusive, and long-term oriented sustainability framework for port operations.

Limitation and future research : The research on sustainability indicators at Panjang Port, Bandar Lampung faces significant limitations and presents opportunities for future research. The key limitations encompass several critical areas: insufficient historical data and stakeholder information access, the inherent complexity of port systems with their interconnected components and external influences, methodological constraints including the lack of comprehensive theoretical frameworks, resource limitations in terms of time, budget, and expertise, and the challenge of adapting to dynamic changes that affect indicator relevance. Looking ahead, the research agenda focuses on developing comprehensive theoretical frameworks that integrate economic, social, and environmental dimensions of sustainability. This includes implementing advanced data collection methods through enhanced stakeholder collaboration and technological solutions, developing robust measurement methodologies that combine quantitative and qualitative approaches, conducting longitudinal studies with real-time monitoring systems, and fostering interdisciplinary collaboration among researchers and stakeholders. These future directions aim to establish more comprehensive, accurate, and relevant sustainability indicators while addressing current limitations through long-term monitoring, inclusive stakeholder engagement, and adaptive management practices, ultimately contributing to the overall sustainability of port operations.

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