KJMS 2025 VOL.7 (1): 270-281

KDU Journal of Multidisciplinary Studies (KJMS)
Volume 7. Issue 1 July 2025
DOI: https://doi.org/10.4038/kjms.v7i1.180

INVESTIGATION OF OPERATIONAL & PROCESS WASTE TYPES IN SRI LANKAN MARITIME SEAWORTHINESS PROCESS

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ABSTRACT

Technical seaworthiness in maritime operations is resource-intensive, demanding operational efficiency through waste reduction. This study investigates waste types in this sector, which faces unique challenges beyond conventional manufacturing. Using a qualitative, single case study design within an interpretivist paradigm, the research explored the nuanced interactions of waste in Sri Lankan maritime technical seaworthiness processes. Eleven in-depth interviews and five focus group discussions were used to collect rich and context specific data form the participants' through subjective experiences. Eight key waste categories emerged: unnecessary data processing, capacity constraints, lack of standardisation, poor governance, inadequate human resources, inconsistent culture, supply chain inefficiencies, and excessive bureaucracy. Contributing factors included poor data accessibility, centralisation issues, resource scarcity, regulatory adherence, and insufficient training. Categorisation of these wastes as value-added, non-value-added and necessary non-value-added activities further clarified their impact. This study offers a framework for minimising non-value-added activities and optimising others, enhancing operational performance. It provides critical insights into operational and process inefficiencies within the Sri Lankan maritime context, guiding strategies for waste reduction and improved efficiency.

KEYWORDS: *Wastes, Maritime Technical Processes, Operational Efficiency, Non-Value-Added, Necessary Non-Value-Added Activities, Value-Added Activities*

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1. INTRODUCTION

Operational efficiency, a cornerstone of organisational success, demands the minimisation of waste and optimisation of resources. While lean manufacturing principles, identified seven traditional wastes, overproduction, waiting, unnecessary transportation, inappropriate processing, unnecessary inventory, unnecessary motion, and defects. These seven wastes have an interpretation in two aspects, process and operations. Later, three more wastes were identified as unused worker creativity (Liker, 2004), environment waste (Mohd, et al., 2017) and data waste (Alieva & von Haartman, 2020).

Waste is classified into three types according to the concept of lean by offering another definition. These are value-added (VA) waste, non-value-added (NVA) waste, and necessary non-value-added (NNVA) waste. In general, three basic categories are related to Muda: NVA, Mura: variations in process quality, cost, and delivery, and Muri: unreasonableness; overburden (Schonberger, 1982 ; Ohno, 1988)

Value is related to things that come out of production and waste is related to things and activities relevant to things coming out of production and inside production. In the context of transformation flow value theory (TFV), these classifications of waste directly impact the transformation of resources and activities through flow to the customer. Muda represents activities that add no value, directly disrupting flow. Mura introduces variability, creating inconsistent flow, and Muri overburdens the system, causing flow bottlenecks. Therefore, understanding and eliminating these forms of waste is critical to optimising transformation, flow and value within any processes.

Complementing Lean methodologies, the Theory of Constraints (TOC) offers a valuable perspective by focusing on identifying and managing the "constraints" that limit system throughput. In operations, these constraints can range from physical limitations to organisational bottlenecks.

Unlike traditional manufacturing, the maritime sector faces unique challenges, including stringent regulations, complex supply chains, and the criticality of safety and operational reliability (Manea, et al., 2021). These factors, particularly hierarchical organisational structures and strict regulatory demands, can create communication barriers, information flow bottlenecks, and hinder the effective implementation of Lean principles for higher operational efficiency (Hibadullah, et al., 2014). Although traditional wastes, have been extensively studied by many scholars, research within the maritime domain has often overlooked non-traditional wastes.

This research comprehensively investigates the systemic inefficiencies in maritime seaworthiness processes, focusing on how wastes stemming from organisational culture and information flow interact. It aims to explain the underlying mechanisms of their impact on operational efficiency, analyse the moderating influence of the maritime operational context, and ultimately inform the adaptation of Lean implementation models for this unique environment.

2. LITERATURE REVIEW

Technical seaworthiness involves a ‘whole system approach’. It encompasses both short-term and long-term factors. Effective seaworthiness requires attention to technical reliability, support functions, and a comprehensive vessel life cycle management strategy (Wu, et al., 2023). This includes factors such as maintenance practices, crew training, regulatory compliance, and resource allocation (Albert, et al., 2015). By ensuring that these elements are adequately addressed, organisations can improve the operational efficiency and safety of their maritime assets (Tobias, 2018).

A ship, regardless of its size or role, must be a safe environment for both crew and passengers. This is a fundamental objective that underpins all maritime operations. To ensure safety, each vessel requires regular maintenance and inspections. Maintenance activities can be broadly classified into two categories. The first category consists of regular or routine checks and second, major maintenance/ periodic maintenance, which requires dry docking and where the ship is unavailable for operations.

The technical seaworthiness process requires a wide range of resources to ensure optimal vessel performance. Infrastructure, including dry docks, slips, and well-equipped workshops, is essential for performing necessary repairs and maintenance (Manea, et al., 2021). Streamlined processes and efficient workflows are crucial to minimising delays and optimising resource utilisation (Ahmad, et al., 2023). Adequate inventory of spare parts and components is vital to ensure timely repairs and avoid disruptions (Maria & Massimiliano, 2013). A skilled workforce with appropriate training and experience is indispensable for carrying out technical tasks effectively (Sharma & Tae-eun, 2021). Efficient transportation systems are required to facilitate the movement of personnel, materials, and equipment (Wu, et al., 2023). Modern and reliable equipment and machinery are essential to perform maintenance and repairs efficiently (Manea, et al., 2021). The adoption of advanced technology can enhance the effectiveness and efficiency of technical processes (Bogusz, et al., 2021). A well-structured organisation with clear roles and responsibilities is essential for effective coordination and collaboration (Sharma & Tae-eun, 2021). Sound corporate governance practices ensure transparency, accountability, and ethical conduct. A favourable environment, including geography, supportive legal and political frameworks, and adequate financial resources, is essential for the successful implementation of technical seaworthiness processes (Llanto & Gonzalez, 2007).

The theoretical framework of the theory of TFV posits that organisational success is directly linked to and measured by operational efficiency. The authors of (Prajogo, et al., 2012) found that the primary objectives of operational efficiency are to reduce cost and minimise waste to improve productivity and cost effectiveness. This concept was also correlated with financial metrics, since the effective transformation of raw materials through an innovative process to quality finished goods with minimum wastage (Blome, et al., 2013) are indicators of operational efficiency. Measuring this efficiency ensures the alignment of organisational activities with strategic goals (Khanchanapong, et al., 2014).

Through a comprehensive review of the literature that spanned from 2010 to 2024, various types of traditional and non-traditional waste and their underlying causes were identified. Overproduction is simply defined as producing more than what is needed or before it is needed. Factors of worker participation, planning inefficiencies, market forces, and manufacturing involvement (Rahmanasari, et al., 2021) can lead to excess inventory, tying up capital, and increasing storage costs (Wilson, et al., 2012; Sharma, et al., 2014; Acero, et al., 2019)

As Rahmanasari, et al., (2021) found that unnecessary transportation, resulting from poor planning, inefficient distribution, supply chain problems, and process failures. Furthermore, handling costs and lead to delays (Hibadullah, et al., 2014; Kučerová, et al., 2015; Chan, et al., 2019). In the research domain, this involves the inefficient movement of technicians and materials between workshops and stores. Relatively unnecessary motion, driven by poor human resource management, layout, process, and workshop-related issues leading to fatigue and reduced productivity.

The study conducted by Kamalahmadi & Parast, (2017) revealed that defects result from poor inspection, planning, material quality, processes and quality checks, leading to rework and increased costs.

In the maritime context, this might involve faulty repairs or maintenance activities that require re-work and continuous system failures.

Inappropriate processing, driven by organisational culture, outdated technology, customer focus, waste identification, worker empowerment, and planning (Silva & Warnapura, 2021), this leads to unnecessary steps and increased repair times (Rydzkowski, et al., 2018) leading to delays and reduced throughput. In the maritime context, this might involve delays in obtaining spare parts or waiting for dry-docking slots/slipping.

These traditional wastes are well-documented in the literature and interconnected/contributed to systemic inefficiencies. However, the technical process of seaworthiness presents unique challenges that require a broader perspective on waste. This necessitates an exploration of non-traditional wastes.

Unnecessary Data Processing, characterised by data inefficiency, poor management contribution, security inefficiencies, and unreliable data (Alieva & von Haartman, 2020) represents a significant paradox from the traditional focus on physical waste. This research argues that these non-traditional wastes are not outliers in their impact, but rather critical, systemic inefficiencies whose subtle nature has led to their underestimation. In parallel to the TFV theory, this waste disrupts the smooth flow of information, for transformation, flow of processes, and value creation. Further, in the context of TOC unnecessary data processing is a constraint slowing the entire processes leading to delays in maintenance, repair, inspection, and throughput of the process.

Inefficient Supply Chain Performance, Focused Logistics, Vendor Participation, Transportation, Inefficient Production Processes, and Source Selection (Bashira, et al., 2020) influenced by poor IT contribution, shows the interconnectedness of traditional and non-traditional wastes. This leads to traditional waste of waiting. This disrupts the flow of material and services, thus delaying transformation and flows as prescribed in TFV theory. In the perspective of TOC, this is a critical constraint restricting organisational ability to ensure seaworthiness of ships/craft.

Inconsistency of Organisational Culture, represent resistance to change, lack of employee involvement, poor communication, a poor culture of continuous improvement, lack of collaboration, and lack of leadership (Chan, et al., 2019) signifies 'Mura'. Cultural resistance hinders the application of new technologies and processes, which leads to inappropriate processing, and defects. According to TOC, poor organisational culture acts as a constraint hindering effectiveness of initiatives. In the context of TFV theory, organisational culture hinders collaboration and communication, and it thus disturbs efficient flow, transformation, and value creation.

Poor Human Resource Practices, Incapable, inefficient, incompletely focused, poorly skilled, vividly directed, insufficiently motivated, and strategically not independent employees (Dibia & Onuh, 2010) directly impact unnecessary motion and defects. Unskilled workers require more movement to complete work assigned, and this leads to more errors adding waste. In the TOC and TFV theory this leading to limiting organisational capability to completion of work as constraint and waste.

Poor Corporate Governance, Inappropriate resource allocation, rigid rules and orders, lack of accountability, overlooking risk factors, and the absence of clear performance metrics (Hong, et al., 2018) can lead to waiting and inappropriate processing. According to the TFV theory, these wastes disrupt resource for transformation through flows. This is a high constraint according to TOC denying organisational ability to minimise wastes.

Ineffective Capacity, caused by old-fashioned equipment, process shutdowns, poor control, poor maintenance planning, lack of loading/unloading machines, and technology obsolescence (Rahmanasari, et al., 2021) directly impacts waiting and overproduction. In the perspective of TFV and TOC this delayed the flow and value, becoming critical constraint by limiting organisational ability.

3. METHODOLOGY

This study employed a qualitative single case study design, grounded in an interpretivist paradigm, to explore the complex interactions of traditional and non-traditional types of waste. An interpretivist approach was chosen as it allows for a deep understanding of the subjective meanings and experiences of the participants, crucial for investigating the nuanced nature of waste types. The single case study design was selected as only Sri Lanka Navy (SLN) and Colombo Dockyard Limited (CDL) in Sri Lanka involve in technical seaworthiness process, in slipping and dry docking for larger vessels. The Sri Lanka Navy (SLN) was selected as the single case for this study because it addresses most of the research objectives and provides a unique context for exploring the subjective meanings and interpretations of the participants.

Data Collection: Data were collected through 11 in-depth interviews and 5 Focus Group Discussions (FGDs). The target population comprised officers within the Sri Lanka Navy's (SLN) Engineering and Electrical and Electronic departments. The sample was selected using purposive (judgmental) sampling, specifically to ensure representation across strategic, operational, and tactical levels. This method allowed for the selection of officers based on their seniority, in-depth knowledge, and extensive experience at each hierarchical layer, thereby assuring the collection of rich, context-specific qualitative data. The interview and focus group guides were developed based on the study's research questions and a comprehensive literature review. Additionally, a content analysis approach was employed to systematically examine relevant organisational documents.

Data Analysis: The transcribed interviews and documentary evidence were analysed using thematic analysis. This process involved several stages: (1) familiarisation with the data through repeated reading, (2) initial coding to identify recurring patterns and themes, (3) searching for broader themes and relationships between codes, (4) reviewing and refining the themes, and (5) defining and naming the final themes. Data saturation was achieved after conducting 7 interviews as by the eight interview, it became evident that no new significant themes were emerging.

Operationalisation of Variables: Independent variables for this study were identified through a comprehensive literature review. These variables included: unnecessary data processing, waste due to lack of capacity, lack of standardisation, poor corporate governance, poor human resource practices, inconsistency of organisational culture, and inefficient supply chain performance. To operationalise these variables, participants' perceptions and experiences related to these factors were examined.

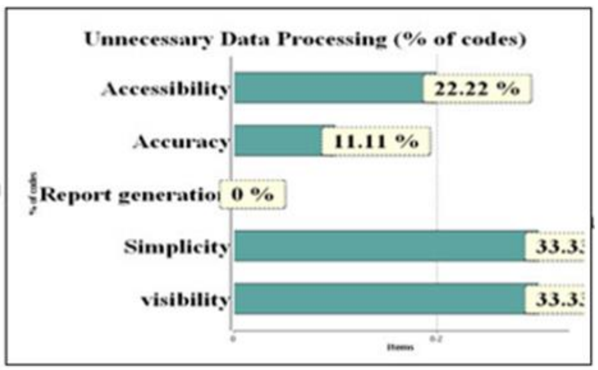
4. RESULTS AND DISCUSSION

Building upon the methodology in Section 3, this section presents the findings of the thematic analysis, conducted using QDA Miner Lite, to explore the interactions of wastes within the SLN's technical seaworthiness processes. A comprehensive coding framework was developed, informed by research questions, variables, literature review factors, and views of the respondents. This framework consisted of key categories, divided into sub codes to capture data nuances. Thematic analysis then identified recurring patterns and relationships, grouping codes into broader themes and interpreting their significance in relation to research questions.

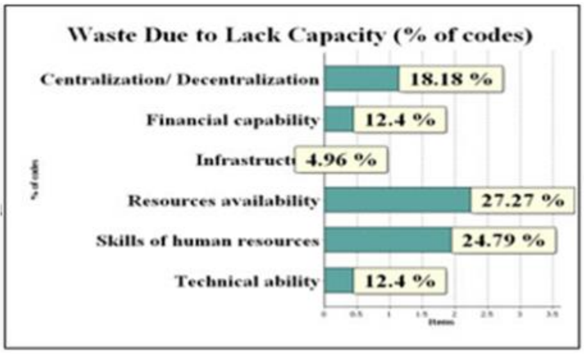
4.1 Quantifying Non-Traditional Waste: Coding Frequencies And Analysis

This process facilitated a comprehensive understanding of traditional and nontraditional waste types within the maritime technical seaworthiness process, including its root causes, impacts, and categorisation. Figures 1 through 8 depict the coding frequencies for each identified non-traditional waste category and its subthemes.

- Unnecessary Data Processing: Figure 1 reveals that accessibility, simplicity, and visibility were the primary subthemes that contributed to the waste from unnecessary data processing. Respondents highlighted various sources of this waste, including system malfunctions, rigid procedures, excessive coding, authorisation issues, offline access limitations, time-consuming processes, resistance to change, and manual report generation. These findings align with previous research by (Alieva & von Haartman, 2020; Breuer, et al., 2020; Mangold & Faulds, 2016).



Figure; 1 Coding Frequency Data Processing

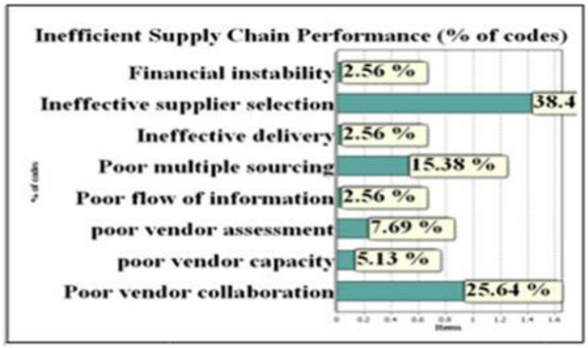


Figure; 2 Coding Frequency Lack of Capacity

Figure; 3 Coding Frequency Corporate Governance

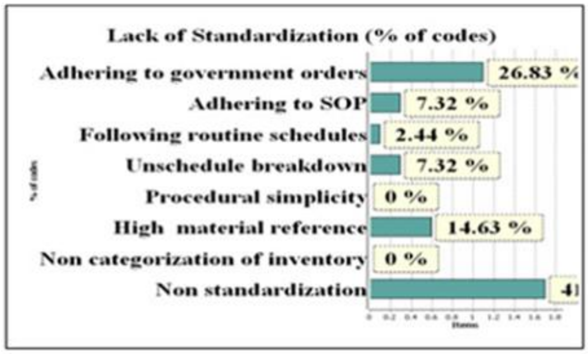
- Lack of Capacity**:** Figure;2 illustrates that centralisation/ decentralisation, resource availability, and human resource skills were the main subthemes contributing to waste caused by lack of capacity. Respondents cited centralised systems, conflicting decisions, outsourcing issues, equipment shortages, and skill gaps as key sources of waste. Rahmanasari, et al., (2021) view this contxt as outdated technology and lack of machinery.

- Poor Corporate Governance: Figure 3 shows waste caused by poor corporate governance, with key contributors' adherence to government orders, lack of common goals, and ineffective command and control. Respondents cited rigid purchasing, cost-driven procurement, departmental silos, misaligned objectives, and unequal workload as root causes. They also highlighted issues with teamwork, information sharing, centralised leadership, and unrecognised contributions. The results of this study corroborate the findings of Hong et al. (2018).



Figure; 4 Coding Frequency Supply Chain Performance

- Inefficient Supply Chain Performance**:** Figure 4 illustrates waste from inefficient supply chains, primarily due to poor supplier selection and collaboration. Root causes included lack of ineffective supplier selection, poor vendor collaborations, and poor multiple sourcing. Previous studies (Bashira, et al., 2020) also demonstrate waste from nonoptimal stocking and supplier interactions, leading to material flow inefficiencies.



Figure; 5 Coding Frequency Lack of Standardization

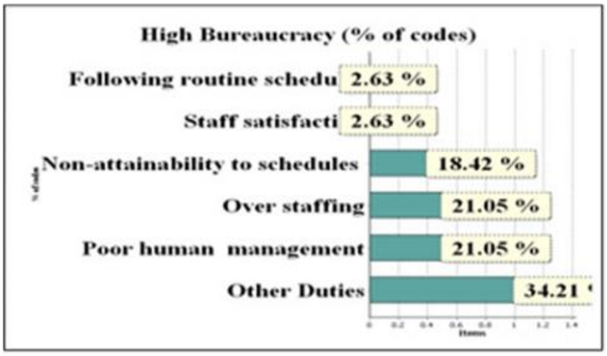
- Lack of Standardisation: Figure 5 indicates that adherence to government orders and non-standardised inventory were major contributors to waste from lack of standardisation. Respondents cited high store variety, equipment specifications, compliance costs, and ownership issues as root causes. These findings, supported by prior research (Bashira, et al., 2020) reveal that non-standardised processes lead to over processing, increased worker motions, and potential customer dissatisfaction. This study reaffirms the critical role of standardisation in waste reduction.

- Poor Human Resource Management: Figure 6 shows a lack of training as the main waste driver from poor human resource management, due to the lack of OEM training. This is further caused by insufficient funding and language barriers. Research confirms that human resource mismanagement causes operational waste, importance of training, workload balance, and employee knowledge for waste reduction. These findings reinforce the critical role of effective human resource management in minimising waste. These were alined with Ahmad & Siti, (2019) studes.

Figure; 6 Coding Frequency Poor Human Resources

Figure; 7 Coding Frequency Organizational Culture

- Inconsistent Organisational Culture: Figure 7 shows inconsistent organisational culture, primarily negative perceptions, as a waste driver. The root causes included poor management, lack of participation, and poor supervision. Research (Rydzkowski, et al., 2018) emphasises organisational culture's role in waste reduction. Studies highlight management commitment, communication, and key cultural values such as productivity and efficiency. This study confirms that effective leadership and a supportive culture are essential to minimise waste.



Figure; 8 Coding Frequency High Bureaucracy

High Bureaucracy: Figure 8 shows high bureaucracy, including competing duties and delays, as a waste driver. This was not a pre-identified variable but emerged from respondent data. Respondents cited emergency responses, meetings, and inflexible procedures as root causes. While research (Chan, et al., 2019) discusses the general negative impact of bureaucracy on waste reduction, the specific finding of 'high bureaucracy' as a primary waste driver in this context emerged from respondent data. Studies highlight the importance of employee involvement and positive worker attitudes. This study confirms that addressing bureaucracy, a respondent-driven insight, minimises waste.

4.2 Root Causes of Non-traditional Waste Accumulation

Table 1 provides a detailed summary of the identified non-traditional waste types, their contributing factors, and the underlying root causes as derived from the qualitative data. This table systematically categorises the origins of these wastes, revealing a complex interplay of systemic issues.

Table: 1 Root Causes for Non-traditional Waste Accumulation

Non-traditional waste type	Contributing Factors	Root Causes
Unnecessary Data Processing	Accessibility	Non-integration of logistics management, rigid procedures
	Simplicity	Excessive spare part coding and time-consuming processes
	Visibility	Authorisation, offline access limitations, manual report generation
Waste Due to lack of Capacity	Centralization/ decentralistion	Centralised stores/purchasing, decentralised transport systems, conflicting decision-making processes

	Resource availability	Outsource docking, insufficient specialised vehicles/ equipment
	Human resource skills	Skilled labour shortages, and inadequate training
Poor corporate governance	Government orders	Compulsory adherence, rigid purchasing practices, cost-driven procurement, hindered flexibility
	Lack focus on common goals	Departmental silos, competing objectives, misaligned functions
	Ineffective command and control	Unequal workload distribution, lack of teamwork and respect, limited information sharing, centralised leadership, and unrecognised contributions
Inefficient Supply Chain Performance	Poor vendor collaboration	Poor information sharing/'relationships/communication, rigid regulations, limited and third-party suppliers, long lead times
Lack of standardisation	Government orders	General equipment specifications
	Non-standardised	High variety of stores, ownership challenges
Poor Human Resource	Lack of training	Insufficient funding, lack of advanced training, poor dissemination of knowledge through seniors, poor English language skills
Inconsistency of Organisational culture	Perceived organisational culture	Negative perception, poor supervision/mentoring/leadership non-participative in decision making, not believing collective responsibility
High bureaucracy	Other duties	Emergency responses, rigid procedures, routines, security duties, and lack of flexibility

4.3 Mechanisms Affecting Operational Efficiency and Lean Implementation Challenges

The analysis revealed that the identified wastes affect operational efficiency in maritime seaworthiness through several key mechanisms, primarily by generating various categories of activities as depicted in Table 2. This table provides a detailed overview of how these wastes manifest in activities classified as Non-Value-Added (NVA), Necessary Non-Value-Added (NNVA), and Value-Added (VA), and their direct impact on operational efficiency. The findings in Table 2 illustrate:

- **Prevalence of NVA Activities:** NVA activities, such as limited offline access, rigid procedures, time-consuming processes, manual report generation, excessive transportation, administration, and poor vendor collaboration, were frequently identified. These activities directly consume resources.
- **Identification of NNVA Activities:** Certain activities, while not directly adding value, were deemed necessary due to existing regulations or organisational structures. Examples include authorisation requirements, excessive spare part coding, compulsory adherence to government orders, and emergency/security duties. These highlight areas

Table 2: Waste activities FFECTING Maritime technical Seaworthiness in the SLN

Subtheme	NVA	NNVA	VA	Impact to Operational efficiency
Accessibility	Limited off-line, dashboard access change resistance	Authorisation requirements	Accountability	Limited decision-making, Inefficiencies in accountability
Simplicity	Rigid procedures time consuming	excessive spare part coding	Transparency	
Visibility	Manual report generation	Limited dashboard access	Sharing information	
Centralisation / Decentralisation	Excessive transportation/ administration	Personal agonies	Centralised stores	Reduced adaptability, Increased costs
Resources availability	No capacity for docking	High expenditure for docking	centralised resources	Decreased productivity, increased costs
Skills of human resources	Recruiting low skills workers	Type training, trained workers leaving SLN	Task Expertising	Poor quality, Increased costs, unproductivity
Adhering to government orders	Rigid purchasing practices, limited information	Compulsory adherence to orders, Centralised leadership	Competing objectives, accountability/ transparency	Flexibility limitations, Increased costs, Reduced competitiveness
Not Focus to common goal	Misaligned functions	Unrecognised contributions		Lack of alignment and motivation, Indecision
Command & control	Ineffective control, silo Department	Centralised leadership	Law & order	Ineffective leadership, Change Resistance
Role of top management	Officer rotation in appointment	Welfare of officers		Lack of focus, change resistance, Indecision
Poor vendor collaboration	Information/ Relationship gaps	Competitive quotation		Delays, Quality issues, Increased costs
Non standardisation	High variety of spares purchases	Grant from overseas, regulations		Increased costs Inefficiencies
Lack of training	Insufficient Funds training	Substandard recruiting to technical works		Increased errors, Lower morale, less productivity
Perceived organisational culture	Non-participative decision, gaps in responsibility	Organisational ethics values & norms	Command & control	Negative attitudes, Inefficiencies, Increased costs
Other duties	Bureaucratic procedures and a lack of flexibility	Emergency and security duties, welfare activities, meetings	Social responsibility	Distracted focus, Overloaded workload, Ineffective prioritisation
Poor human management	Not identify ideal professionals	Appointment pattern, personal requirement		Lack of motivation, Turnover, Ineffective decision-making

where current operational practices, though non-value-adding, are perceived as unavoidable.

- **Impact on VA Activities:** The proliferation of NVA and NNVA activities was found to directly impede the efficiency and effectiveness of core Value-Added activities e.g., actual maintenance, skilled repairs, effective decision-making, and achieving high operational states. The observed impacts on operational efficiency include limited decision-making, reduced adaptability, increased costs, decreased productivity, and poor quality.

4.4 Moderating Role of the Maritime Operational Context

The specific organisational context of maritime operations, particularly within the SLN, was found to significantly moderate the relationship between these interacting wastes and operational efficiency. The analysis revealed that the unique characteristics of the SLN environment amplify or alter the impact of these wastes on key operational outcomes:

- Financial Achievement: The SLN, as a government entity, operates under strict budgetary constraints. The non-traditional wastes identified, such as "Inefficient Supply Chain Performance" and "Lack of Standardisation”. Directly impact financial achievement through increased procurement costs and operational inefficiencies. Adapting Lean models offers cost-effective solutions and clear financial returns on investments.
- Scheduling Work efficiently and effectively: The SLN require precise scheduling of maintenance and repair activities. "Unnecessary Data Processing" and "High Bureaucracy" contribute to delays and inefficiencies in scheduling. Lean implementation streamlined workflows and real-time data to enable agile scheduling and minimise downtime.
- Working Collaboratively in Cross-Functional Departments: The SLN's structure involves numerous specialised departments, requiring seamless collaboration for effective seaworthiness operations. The “Inconsistent Organisational Culture" and "Not Focus to Common Goal" highlight the challenges of cross-functional collaboration. Lean offer team-based problem-solving and shared accountability to overcome departmental silos.
- Resource Optimisation: The SLN faces resource constraints. The “Waste Due to Lack of Capacity" and "Poor Human Resource" directly impact resource optimisation. Strategic resource allocation, leveraging technology, and investing in training to maximise Lean application.
- Achieving a High Operational State of Vessels: The ultimate goal of the SLN is to maintain a high operational state of its vessels. Non-traditional wastes directly hinder this objective by compromising maintenance quality and increasing the risk of defects. Adapting Lean models requires a focus on standardised procedures, rigorous quality control, and proactive maintenance to ensure vessel readiness.

5. Implications for Practice and Society

Implications for practice

- **Improving Operational Efficiency:** The findings of this study assist SLN and other maritime organisations identify and address traditional and non-traditional waste types, leading to improved operational efficiency, reduced costs, and improved vessel seaworthiness. This can be achieved by streamlining processes, improving communication, and investing in training and technology.
- **Adapting Lean Implementation Models:** Research identified the challenges of implementing Lean principles in the maritime context and suggests the need for tailored approaches that consider the unique organisational and operational characteristics of the domain. This includes addressing the hierarchical structure, bureaucratic procedures, and resource constraints that can hinder Lean adoption.
- **Enhancing Training and Development:** The findings highlight the importance of training and development programmes to address skill gaps and promote a Lean mindset among employees, such as improving technical skills, fostering teamwork, and promoting a culture of continuous improvement.
- **Strengthening Corporate Governance:** Research emphasises the role of strong corporate governance in promoting transparency, accountability, and ethical conduct, which are essential for Lean implementation. Organisations can strengthen corporate governance through measures such as clear policies, open communication channels, and effective performance management systems.

Implications for Society

- **Enhancing National Security:** By improving the operational efficiency and seaworthiness of naval vessels, this research contributed to enhancing national security and ensuring the readiness of the SLN to carry out its mission of protecting Sri Lanka's maritime interests.
- **Promoting Economic Development:** The findings of this study can help improve the efficiency and competitiveness of the maritime industry, which plays a crucial role in Sri Lanka's economic development by facilitating trade, transportation, and tourism.
- **Enhancing Public Safety:** By promoting a culture of safety and continuous improvement, this research can contribute to enhancing public safety in maritime operations, reducing the risk of accidents and incidents that could harm people or the environment.

6. CONCLUSIONS

This study addressed the critical challenge of operational efficiency in Sri Lankan maritime technical seaworthiness, a resource-intensive sector facing unique complexities beyond traditional manufacturing. Through a qualitative, interpretivist case study, eight categories of wastes were identified, including data processing inefficiencies, capacity constraints, standardisation issues, governance lapses, human resource inadequacies, cultural inconsistencies, supply chain weaknesses, and bureaucratic hurdles. These were further analysed by categorising them as value-added, non-value-added, and necessary non-value-added activities, providing a nuanced understanding of their impact. The study highlights the significance of addressing these wastes to enhance operational performance, offering a practical framework for minimising non-value-added activities and optimising resource utilisation.

Moving forward, several research avenues are proposed. Firstly, longitudinal studies are needed to evaluate the long-term impact of identified wastes on financial performance, sustainability, and reputation. Secondly, comparative analyses with similar maritime organisations can identify best practices and benchmarks. Thirdly, the potential of emerging technologies like AI and blockchain should be explored for waste reduction and efficiency enhancement. These future research directions will build upon the current findings, offering deeper insights and more effective strategies for improving operational efficiency in the maritime sector.

Author Contributions: Conceptualisation, RACN, RPH, and UG; methodology, RPH; validation, RACN, RPH, and UG; investigation, RACN; data curation, RACN; writing—original draft preparation, RACN; Writing—review and editing, RACN and RPH; visualisation, RACN; supervision, RPH and UG. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Data are available from the authors by request.

7. ACKNOWLEDGMENTS:

We express our utmost gratitude to the editors and reviewers for their invaluable feedback. We extend our sincere appreciation to Commander of the Sri Lanka Navy and Director Generals Engineering, Logistics and Electrical& Electronic Engineering for granting permission to conduct the research and essential assistance during the process of data collection and paper development.

Conflicts of Interest: The authors declare no conflicts.

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