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Correspondence should be addressed to Sawera Fatima; sawerakhokhar4@gmail.com

RESEARCH ARTICLE

Evaluating the Accuracy of Neural Network Algorithms in Analyzing Consumer Purchase Patterns: The Impact of AI Technology on Environmental Performance in Pakistan's Shipbuilding Industry

Ali Raza [a] Kirshan Kumar Luhana [b] Imran Khan Keerio [c] Sawera Fatima [d] Azeem Akhtar Bhatti [e]

Abstract: The objective of this research is to explore the neural network algorithms Approaches and AI technology on Environmental Performance: The Role of Green Procurement, Eco-Design, Waste Management, and Energy Efficiency in the Shipbuilding sector/Industry of Pakistan. A survey questionnaire was adopted to analyse the impact and the role of Green Procurement, Eco Design, Waste Management, and Energy Efficiency in the Shipbuilding Industry/sector of Pakistan. The respondents were reached through random convenient sampling. More than 300 responses were collected from the shipbuilding sector including supply chain members, technicians, supervisors, executives and managers. The study analyses the responses through the SMART PLS-04. The study finding has exposed that four neural network algorithm approaches in the supply chain Green Procurement (GP), Eco-Design (ED), Waste Management (WM) and Energy Efficiency (EE) have a positive impact on Environmental Performance (EP) in shipbuilding sector of Pakistan. The research is limited to the shipbuilding sector of Pakistan and there are only four approaches have been taken for this study. This research will help concerned managers in the shipbuilding sector of Pakistan to run their operations activities effectively by implementing GP, ED, WM, and EE approaches.

Keywords: Neural Network Algorithms, Shipbuilding, AI Technology, Environmental Performance, Eco-Design, Green Procurement, Waste Management, Energy Efficiency

Introduction

The shipbuilding industry is a key contributor to the economic development of individual countries by promoting employment, trade, war and defence, and technology. However, it is faced with an urgent need to mitigate environmental damage like many other industries. Adopting neural net algorithms in their factory-responsive practices has been presented as a vital technology to counter many such challenges and ensure the long-term viability of the globally competitive shipbuilding industry (Prechelt, 1996). This study also investigates the effects of neural network algorithms in the Pakistan shipbuilding industry.

Shipbuilding is inherently a resource-intensive, emissions, and waste-generating process, making it one of the key contributors to environmental degradation. There is a growing concern about the industry's long-term sustainability, and whether traditional practices and materials are fit in an age where sustainability is paramount (Yao, 1993). Together these challenges have led to the introduction of the neural network

[a] Assistant Manager, Student Support Centre (SSC), Bahria University, Karachi, Sindh, Pakistan.
Email: alirazam7917@gmail.com
[b] Assistant Professor, Department of Computer Science, Sindh University, Laar Campus Badin, Sindh, Pakistan.
Email: Kirshan.luhano@usindh.edu.pk
[c] Lecturer, Department of Computer Science, Sindh Madressatul Islam University, Karachi, Sindh, Pakistan.
Email: imran_keerio@yahoo.com
[d] University of Mirpurkhas, Sindh, Pakistan. Email: sawerakhokhar4@gmail.com
[e] Assistant Professor, Department of Commerce, Sindh University, Laar Campus Badin, Sindh, Pakistan.
Email: azeem.bhatti@usindh.edu.pk

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algorithm concept as a framework to govern how principles of environmental sustainability can be applied in supply chain practices (Duan et al., 2025).

Neural network algorithm is a collective term for a variety of practices seeking to minimize the environmental cost of the entire supply chain, while still maximizing operational efficiency and cost-effectiveness (Frean, 1990). It includes eco-design, green procurement, waste management, and energy efficiency as well as other measures that streamline their resource use, emissions, and waste along with their entire shipbuilding process. With the adoption of good practices from neural network algorithms, the shipbuilding industry can help preserve the environment, adapt to regulatory requirements, increase its operational efficiency, and improve its competitiveness (Hailiang et al., 2023).

Neural network algorithms hold an even greater significance in the shipbuilding industry in light of the growing global focus on sustainability and environmental stewardship. International conventions regulate pollution and environmentally friendly practices in the maritime industry (Zhai et al., 2021). In addition to being a lawful requirement, compliance with these regulations is essential for upholding the integrity of the industry while also keeping pace with increasing customer demand for sustainable products and services.

Now coming to Pakistan's shipbuilding industry potential, it holds huge potential for economic growth and development. While the country aims to build more maritime-related infrastructure and make the most out of its strategic geographical position, the industry must be done sustainably and in an eco-friendly manner (Khokhar et al., 2020). Examining neural network algorithm practices in the shipbuilding industry of Pakistan will provide insight into the existing level of green initiatives, recognize obstacles, and suggest measures to ameliorate sustainability.

This study would aim at the applications of neural network algorithm practices in the shipbuilding industry in Pakistan and would help in gaining insights into the challenges and opportunities in implementing these neural network algorithm practices (Cao et al., 2018). The study attempts to address the lack of literature concerning neural network algorithm adoption, focusing on its perceived benefits, barriers, and enablers, thereby adding to the body of literature and aiding policymakers, industry practitioners, and stakeholders towards sustainability Khokhar et al., 2020).

In short, this study aims to identify ways to promote sustainability in the shipbuilding sector of Pakistan. It aims to enable the industry to migrate to environmentally friendly solutions, enhance competitiveness, and promote a sustainable development agenda by analysing how practices around neural network algorithms affect carbon footprint. The following will explore the specific elements of neural network algorithm development, assess the status of the shipbuilding sector in Pakistan, and develop guidelines for its sustainable development (Hassan et al., 2017).

The shipbuilding industry of Pakistan has a long history and in recent years, it has been on remarkable progress and development. Geographically, the nation's vital coastal location toward the Arabian Sea creates great potential for seafaring trade (Hou et al., 2021). Shipbuilding is an essential sector for domestic trade and the international economy; it satisfies the need for commercial vessels, offshore structures, and naval ships. Pakistan has gone to great lengths to build up its shipbuilding potential over the years. The government also supports the policies oriented towards building the industry and investing in the infrastructure. Multiple public and private shipyards have also been set up throughout Karachi and Gwadar's coasts, supporting the industry and creating more jobs (Khokhar et al., 2022).

The shipbuilding industrial sector in Pakistan supports a wide range of market segments from cargo ships and fishing vessels to naval ships and offshore platforms. It can serve the domestic shipbuilding requirements of the country and also look for international opportunities. As the industry has great growth potential, it is in harmony with the government's vision for economic diversification, job creation, and enhancement of the country's maritime capabilities (Vakili et al., 2017).

Over the years the Shipbuilding industry has encountered various types of environmental issues. The process of building and running ships requires vast amounts of resources and the environmental impact is great. These impacts relate to air and water pollution, carbon emissions, and the generation of solid and liquid waste (Raza et al., 2024). Add to that the industry's dependence on fossil fuels as well as the use of materials that may be harmful, and it begin to get a sense of the environmental challenges it faces.

Additionally, the worldwide challenges posed by climate change, resource depletion, and sustainability have triggered a transition to more sustainable practices across industries (Newlander et al., 2015). As a result, the global shipbuilding industry has started embracing sustainable solutions to mitigate its environmental footprint.

The green chain operation in the shipbuilding sector is at a very initial stage in Pakistan compared to leading shipbuilding nations like South Korea, Japan, and China, where efforts are being made to incorporate green practices in shipbuilding. Very few studies have focused on exploring the prevalent environmental issues confronting the industry in Pakistan and the possible advantages and opportunities linked with green practices (Sahabuddin et al., 2023).

This study seeks to fill this gap by examining the role of neural network algorithms in the shipbuilding sector of Pakistan. This study will be a valid guideline for the development and rise of green practices in the shipbuilding industry in Pakistan by knowing its meaning and current environmental circumstances, halal means that it will enable a fuller and better understanding of the industry that in local industry that it will be expected to find its place and where it will have the expected place.

As mentioned before, the composite and steel resources-based shipbuilding industry in Pakistan makes it a resource-guzzling and fossil-fuel-intensive activity exposing it to grave environmental challenges. The challenges have to do with air and water pollution, carbon emissions and solid and liquid waste (Khokhar et al., 2023). But in the Shipbuilding world, globally, efforts are being made to switch to sustainability. There is a scarcity of studies on the practices of neural network algorithms and their impact in the context of Pakistan.

However, little research has been conducted on the adoption of neural network algorithms in the shipbuilding industry in Pakistan, resulting in a gap in knowledge regarding the benefits of AI technology on environmental performance (Siddiqui et al., 2023). This highlights the need to understand how shipbuilding companies in Pakistan may implement neural network algorithm practices on their supply chain processes to reduce environmental impact, improve environmental performance and ultimately gain long-term competitive advantage (Yang et al., 2018).

Furthermore, the data does not include the specific barriers and enablers of neural network algorithm adoption in the shipbuilding industries of Pakistan. The identification of barriers and enablers is necessary for formulating effective strategies to tackle barriers and mementoes enablers for achieving successful implementation (Meihui et al., 2023). The Pakistan shipbuilding industry faces critical environmental issues arising from resource-intensive processes, dependence on fossil fuels, and the usage of potentially harmful materials. These challenges translate into pollution in water and air, carbon emissions, and vast amounts of waste. While there are worldwide efforts for sustainability in different industries, few studies have explored the practice and impact of neural network algorithms, in the special context of Pakistan's shipbuilding industry. The resource-based view indicates that neural network algorithm practices are good practices since they help firms achieve superior performance (Khokhar et al., 2022). Many countries worldwide have introduced environmental regulations to limit hazardous output and operational processes. So, many companies have hopped on the"green movement". This trend highlights the significance of neural network algorithms that are associated with much threat to those firms which do not supervise their suppliers for green operations (Yadav & Chandel, 2014). Characteristics of environmental pollution (e.g. particulate

matter, odour, and noise), which are linked with public complaints, were assessed in an industrial shipbuilding complex (Bhatti et al., 2023).

This highlighted knowledge gap is exacerbating a lack of knowledge about the potential disadvantages, advantages and future trends of sustainable practice applied in local shipbuilding, including with this new technology in Pakistan due to a lack of research regarding the adoption of the neural network algorithm specifically in Pakistan's shipbuilding. Therefore, it is essential to explore the practices of neural network algorithms in the supply chain process of a shipbuilding company located in Pakistan to address environmental issues, improve their performance, and develop long-term competition.

In addition, there remains a dearth of insights that elucidate the existing enablers and barriers to the adoption of neural network algorithms in the context of the Pakistan shipbuilding sector specifically. These variables, if recognized and understood, are critical for engaging appropriate strategies, overriding impediments, and taking advantage of enablers to the effective undertaking of neural network algorithm practices.

Problem Statement

Hence, this study attempts to explore the following problem statement:

(a) How does the adoption of a neural network algorithm lead to a reduction in environmental impacts, (b) improved operational efficiency, and (c) enhanced competitiveness in the shipbuilding industry of Pakistan? Furthermore, what are the barriers and enablers in the adoption of neural network algorithms in Pakistan's shipbuilding industry and how can they be efficiently tackled?

Consequently, the problem statement addressed by this research is:

How does the adoption of neural network algorithms impact the shipbuilding industry in Pakistan regarding environmental impact mitigation, operational efficiency improvement, and competitiveness enhancement? Also, what are the barriers and enablers to the adoption of neural network algorithms in the shipbuilding industry in Pakistan, and how can these be addressed effectively?

Research Objectives

The objectives that this research seeks to realize are:

1. This exercise serves to quickly assess the current environmental challenges in the Pakistan shipbuilding industry such as air pollution, water pollution carbon emissions, and waste generation. Objective 1: Data collection and analysis, environmental impact assessment of shipbuilding activities through site visits.
2. To assess the potential influence of neural network algorithms (adoption on the shipbuilding sector in Pakistan regarding the reduction of the environmental damages to increase or decrease emissions and waste generation. In this aim, the efficiency of neural network algorithms practices in reducing the environmental footprint in shipbuilding procedures will be analyzed.
3. To assess the improvement of AI technology environmental performance relating to resource consumption, process cost reduction, and supply chain collaboration and sustainability of shipbuilding companies in Pakistan through practices of neural network algorithms. To accomplish this goal we will analyse operational performance data, interview industry experts, and benchmark best practices.
4. To study the NNA adoption in the shipbuilding industry of Pakistan to regulatory compliance, technology implementation and stakeholder engagement in analysing the pros and cons of NNA usage. To achieve this goal, we will conduct surveys, interviews, and case studies to collect feedback from industry stakeholders.

5. This study aims; (1) to identify the barriers and enablers to neural network algorithm adoption in the shipbuilding industry in Pakistan and (2) to propose strategies for addressing these barriers and leveraging enablers. Accomplishing that goal will mean analyzing data, holding workshops or focus groups, and connecting with key stakeholders to pinpoint challenges and brainstorm actionable solutions.

To develop actionable recommendations for shipbuilding companies, policymakers, and stakeholders to encourage the adoption of NN algorithm practices and to facilitate sustainable growth in the shipbuilding sector in Pakistan. It includes distilling findings, extracting actionable recommendations, and presenting the latter in the form most easily implementable by industry practitioners and policymakers. This research aims to answer the following questions:

What benefits are perceived for the adoption of green procurement, eco-design, waste management and energy efficiency in the shipbuilding industries of Pakistan? Impact of Green Procurement on Resource Utilization in Ship Building Industry of Pakistan. How does eco-design facilitate cost reduction and enhanced supply chain cooperation to optimize AI technology on cap 2759 environmental performance in the shipbuilding industry? How does AI technology on environmental performance improvements in the shipbuilding industry in Pakistan concerning effective waste management? What is the impact of energy-efficient adoption and transformation of operation on AI technology and the environmental performance of the shipbuilding industry? To what extent can practice-oriented directives be given to shipbuilding companies, policymakers, and stakeholders to ASD neural network algorithm-based practices adoption and ensure sustainable growth of the shipbuilding industry of Pakistan?

This research is important for a variety of stakeholders who are part of the shipbuilding industry in Pakistan, as well as from a broader perspective of sustainable practices and neural network algorithms. So the significance of the study can be explained as: BackgroundPurpose: Neural network algorithms have been instrumental in advancing the feasibility of various applications in multiple fields (Raza et al., 2024). This is an important research contribution, given the paucity of similar studies particularly focusing on the contexts surrounding neural network algorithm practices in Pakistan's shipbuilding industry. This will broaden the academic scope and provide new insights for scholars to use on sustainable practices, the supply chain, and the shipbuilding industry, a growing sector in Nigeria. Some formulations of the key message(s) and/or methods based on research findings/practice recommendations for practice: Research findings and practice recommendations derived from the study will be helpful for shipbuilding companies in Pakistan.

In conclusion, these insights provide valuable guidance to help shipbuilding companies consider more suitable and efficient measures of addressing how neural network algorithm adoption and its impact on AI technology can be integrated into the environmental performance of their vessel construction plans, ultimately leading to a more sustainable and efficient maritime industry. Policy Guidance: The outcomes of this research can guide policymakers in Pakistan’s maritime sector to develop policies and regulations that encourage sustainability in shipbuilding. The results could be utilized to develop infrastructures, motivators, and standards that promote neural network algorithm practices among shipbuilding organizations. Overall, research in this area can help develop systemic approaches to promoting sustainable development, minimizing ecological footprints, and enhancing the international competitiveness of the industry. Importance of Environmental Impact:

This study focuses on neural network algorithms and the impact they can have on improving environmental sustainability. The research presents an opportunity to ameliorate shipbuilding-agnostic environmental practices in Pakistan by identifying efficient neural network algorithm practices as well as their implementation in a shipbuilding environment. By implementing sustainable practices like eco-design, waste reduction, and energy efficiency, the industry can lessen its carbon emissions, minimize pollutants,

and help preserve marine ecosystems. Positive Economic Outcomes: The results of the research can contribute to positive economic outcomes for the shipbuilding industry in Pakistan. This will help in lowering the cost of tools that can benefit the industry by increasing operational efficiencies, limiting wastages, and utilizing resources wisely (Khan et al., 2024). As this research has sustainability, AI technology and environmental performance components, its results can catch the international visibility and investments in Pakistan's ship coverings because global customers and stakeholders are focusing on the sustainable field.

The impact of this study can enhance academic knowledge, inform industry practices, guide policy development, support environmental sustainability, and promote economic growth for the shipbuilding industry in Pakistan. These insights will be interests for many stakeholders who want to invest in healthy operations as well as sustainability and want to reduce future costs in shipbuilding. This study is confined to the discovering impact of neural network Practices in the Pakistani shipbuilding industry. Some important aspects of the include: Geographic Setting: The study is focused on the shipbuilding sector in country Pakistan. Comprising shipyards and construction, repair, and maintenance of all kinds of ships on the coastal sites of Karachi and Gwadar. The recommendations and findings are to be localized to the specific context of Pakistan's shipbuilding industry. Industries Under Study: This research focuses on the shipbuilding industry, which comprises public and private shipyards operating within Pakistan. This data includes different types of vessels including cargo ships, fishing vessels, naval ships and offshore structures. We study how neural network algorithm practices are adopted and what impact their actual implementation that we design offers to the shipbuilding supplier chain. Environmental Scope: The volume of waste generated by the shipbuilding industry in Pakistan, the environmental issues in shipyards such as air and water pollution, carbon emissions, and the waste generated by main equipment are other considerations for the research. This restrictive impact has led to the growth of adoption towards alignment of neural network algorithm practices that have been applied in the domain for sustainability and a positive contribution towards the environment (Raza et al., 2024).

Operational Scope: This research on neural network algorithms in the side of the implementation scope of shipbuilding. Utilising sustainable practices thus not only means measuring the effective use of resources and cost savings but also collaborative efforts across the supply chain. From an operational perspective, the research will delve into the benefits and challenges likely associated with adopting neural network algorithms.

Related Title: Stakeholder Scope The stakeholder scope: Data indicates that the shipbuilding industry involves multiple types of stakeholders, and it impacts the shipbuilding sector in multiple ways, both directly and indirectly. This involves shipbuilding companies, employees, suppliers, customers, policymakers and regulatory bodies. The objective is to better understand the viewpoints, objectives, and potential obstacles of various stakeholders, leading to recommendations that account for their needs.

Research Period: This research examines the current and immediate events of the shipbuilding industry in Pakistan. The impact of the paper is to analyze existing environmental challenges, current practices, and emerging neural network algorithm trends. The scope of the research deliberately focuses on neural network algorithms relevant to the shipbuilding sector, excluding other areas of the maritime industry(e.g. port operations, shipping logistics, and maritime regulations) unless directly related to the implementation of neural network algorithm practices based upon the findings of this research.

This research, therefore, will have a focus, which, by defining the scope, would make the analysis comprehensive and focused on the impact or role of neural network algorithms (NNAs) in the shipbuilding industry in Pakistan. These findings and recommendations drawn from this research may help maximize value in the context of a defined scope and assist stakeholders in addressing the environmental challenges, enhancing the AI technology on environmental performance, and supporting the sustainability of the shipbuilding supply chain in Pakistan.

This study is structured around the following:
This research outlines all the background of the study, problem statement, research objectives, research questions, significance, and scope of the study. In this study, we provide a thorough review of existing literature. It addresses important concepts underpinning the use of neural network algorithms as well as their implications for sustainable practices within the shipbuilding industry context. The theoretical framework, existing gaps research rationale and research questions are found in the literature review. This study describes the research design as well as the methods of data collection and analysis employed in this study. It details the research method, the participants and the data collection instruments. The study outlines the data analysis methods and also the ethical issues.

The research presented in this paper deals with the data gathered through Google Forms and other research methods. The research outcome is reflected in this research study in depth which covers the practices of neural network algorithms generated in line with the shipyard industry, as well as the influence of Green Procurement, Eco-Design, Waste Management and Energy Efficiency. The research findings are interpreted and implications of the study are discussed. It juxtaposes the findings with literature, patriarchs, key patterns and themes, and explanations. The research implications for shipbuilding companies, policy-makers, and other stakeholders are also discussed in the study.

The last study summarizes the main findings of the research and gives some final thoughts. It reiterates the research objectives and key contributions and addresses the limitations of this study. The implications of the study are, thus, relevant to shipbuilding companies, policymakers, and future research.

Literature Review

The shipbuilding industry plays a significant role in global trade, transportation and defence of the country, but its operations also have considerable environmental implications. With increasing concerns about climate change and sustainable development, there is a growing need for the shipbuilding industry to adopt practices that minimize its environmental footprint and promote sustainability. Neural network algorithms have emerged as a strategic approach to integrating environmental sustainability principles into supply chain practices in various industries, including shipbuilding (Irshad et al., 2019b). By implementing neural network algorithm practices, organizations can improve their AI technology on Environmental Performance (EP), reduce resource consumption, and enhance their overall competitiveness.

The following is a literature review that compares the current research surrounding neural network algorithms and their similarities in the shipbuilding industry. The identified variables include, amongst others, Green Procurement (GP), Eco-design (ED), Waste Management (WM) and Energy Efficiency (EE), which are critically reviewed, mainly regarding their definitions, interactions and benefits for sustainability in shipbuilding. It is vital for effectively recognizing opportunities and difficulties in the adoption of sustainable practices for the ship-building sector and promoting a positive impact on the environment. The neural network algorithm is a series of practices that concern the minimising environmental impact of the full supply chain and the k e e p ing operation efficiency and economy (Hou et al., 2022). This includes techniques such as eco-design and green procurement as well as measures for waste management, energy efficiency, etc., aimed at reducing resource consumption as well as emissions and waste generation in the shipbuilding process (Kok et al., 2010). The shipbuilding industry develops through the practice of neural network algorithms, minimizing environmental pollution, helping followers of regulators and related agencies, improving the operational efficiency of its production, and contributing to improving AI technology environmental performance (Khaskhelly et al., 2022).

Neural Network Algorithms

Neural network algorithms are part of a strategic approach that incorporates the principles of environmental sustainability into supply chain activities in the shipbuilding industry. This can include green procurement, eco-design, waste management, and energy efficiency. The neural network algorithm seeks to reduce the shipbuilding industry's environmental impact while optimizing operational efficiency and retaining competitiveness (Ouammi et al., 2012). Neural network algorithm practices contribute to environmental pollution reduction, resource utilization efficiency, cost reduction, and increased corporate image and reputation (Khokhar et al., 2024).

Performance on the Environment and AI Technology

Related AI technology on Environmental performance is the quantifiable result of an organization, process, product, or activity that is affected by it in the natural environment. The efficiency of the shipbuilding industry is measured with carbon and water footprints. Some of these are carbon emissions, energy consumption, waste production, and pollution levels (Carbon Emissions, Energy Consumption, Waste Generation, and Pollution Levels in the Shipbuilding Industry). The growing environmental challenges have demanded organizations in the shipbuilding industry to monitor and improve the environmental performance of AI technologies. The application of neural network algorithms to improve AI technology on environmental performance and achieve sustainability objectives was stressed in the studies (Yumei, 2020). The shipbuilding industry can play a role in a greener and more sustainable future by adopting environmentally responsible practices such as reducing emissions, optimizing power consumption, and minimizing waste generation (Menlik et al., 2010).

Green Procurement

For neural network algorithms, green procurement is essential as it involves sourcing eco-friendly materials and components and incorporating them into the shipbuilding process. That means to select suppliers based on their AI technology on environmental performance, researcher use eco-friendly materials and promote sustainable practices up and down the supply chain. Irshad et al. (2019a) state that Green procurement practices reduce the environmental impact of shipbuilding and promote sustainable materials and technologies. Green procurement has been shown in research to provide reduced environmental impact, enhanced product quality, and improved customer satisfaction.

Eco-Design

Eco-design relates to the consideration of eco-design principles of technology in shipbuilding. It strives for energy efficiency, low environmental impact and resource optimization (Khokhar, 2019) Eco-design is the incorporation of practices such as implementing lightweight materials, energy-efficient systems, and creative design strategies into the design process. Adopting and implementing eco-design practices in the shipbuilding process facilitates the construction of environmentally sustainable vessels, hence, supporting meeting the growing demand for energy-efficient transportation (López et al., 2005). Prior research has indicated that eco-design, such as emissions reduction, fuel efficiency improvement, and overall ship sustainability performance, has drawn much attention.

Proper waste management is essential in the shipbuilding industry to control waste generation, encourage recycling, and provide safe disposal of hazardous materials. Waste management includes incorporating methods of waste disposal, segregation of waste, and recycling. Sustainable waste practices can help organizations reduce their environmental footprint, comply with regulations, and achieve a circular economy. Studies highlighted the need for an effective waste management strategy to minimize pollution generation, save resources, and positively enhance the environmental performance of the shipbuilding sector and the AI technology used for such purposes.

Energy efficiency measures include, for example, the installation of new technologies, improved operational practices, and energy-saving efforts in the shipbuilding industry. Organizations can lower operating costs, minimize carbon emissions and improve their environmental sustainability through more energy-efficient practices as described in Table 1 (Khokhar et al., 2020). Energy-efficient practices may involve the utilization of energy-saving propulsion units, optimizing ship hull design to minimize resistance, and establishing the energy utilization control system. Energy efficiency has been highlighted in shipbuilding as an essential factor for achieving sustainability goals and maintaining compliance with regulations (Bhatti et al., 2023).

As depicted in the below figure 1, the roles of neural network algorithms and AI technology as environmental performance factors spanning from green procurement to eco-design and waste management to energy efficiency are all important variables in determining the effective implementation of sustainable shipbuilding practices as per the literature. The interplay and interdependence between these variables are crucial and their successful delivery can help promote sustainability in the shipbuilding industry in an eco-friendlier way.

Table 1

Theoretical Explanation of the Variable

Eco-Design	The shipbuilding industry should be more regulated to enforce eco-design practices. The organization actively incorporates eco-friendly materials in ship construction. Eco-design practices can lead to cost savings and environmental performance.
Energy Efficiency	Shipbuilders in our industry are well-informed about energy-efficient technologies. Energy-efficient ship design is a priority. The shipbuilding industry invests more in research and development of energy-efficient technologies.
Green Procurement	Green procurement is essential for the long-term sustainability of the shipbuilding sector. Green Procurement practices positively influence organizational reputation. Shipyard is committed to reducing the carbon footprint through Green Procurement.
Waste Management	The department promotes the reuse of materials whenever possible. Shipbuilding industries should be legally obligated to meet waste management standards. The shipbuilding industry should invest in waste recycling technologies.
Environmental Performance	There is a focus on minimizing environmental impact in ship design. The production planning and control (PPC) are evaluated considering the environmental performance. Consistently reduces waste and promotes recycling for better environmental performance.

Research Hypotheses

Hypotheses 1: Green Procurement (GP) positively influences AI technology on Environmental Performance (EP).

Hypotheses 2: Eco-design (ED) positively influences AI technology on Environmental Performance (EP).

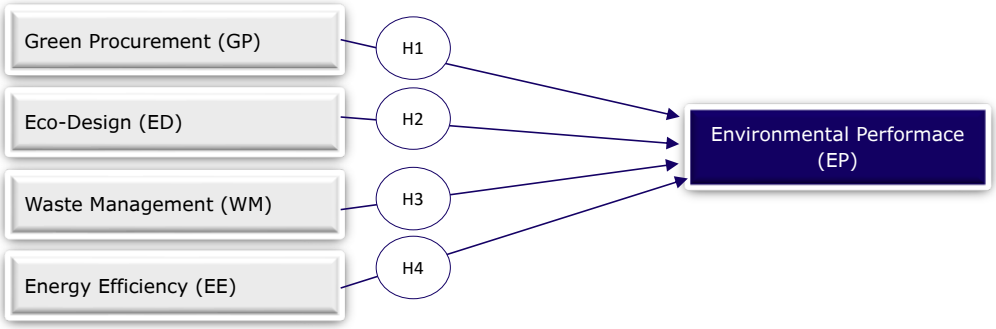
Hypotheses 3: Waste Management (WM) positively influences AI technology on Environmental Performance (EP).

Hypotheses 4: Energy Efficiency (EE) positively influences AI technology on Environmental Performance (EP).

Hypotheses 5: Government Support (GS) positively influences AI technology on Environmental Performance (EP).

Figure 1

Conceptual Framework



Methodology

Research Approach & Type

The research approach for this study is quantitative, quantitative research utilizes statistical methods to measure and analyze data, allowing for objective and systematic investigation of relationships and patterns. Utilizing statistical analysis to examine the relationship between neural network algorithms approaches and AI technology on environmental performance. The deductive approach type is applied, aiming to provide practical solutions for the shipbuilding industry in Pakistan. The exploratory research design allows for a comprehensive exploration of the topic, generating new insights and hypotheses.

Applied research focuses on addressing practical problems or issues and aims to generate practical solutions or recommendations for real-world contexts. In the case of this study, I am investigating the relationship between neural network algorithms approaches and AI technology on environmental performance in the shipbuilding industry in Pakistan, to provide insights and recommendations to improve sustainability practices & AI technology on environmental performance within the industry.

Research Design

In the present study, a cross-sectional research design was utilized. So, in this design, data from different sources is collected at a single point in time. Data will be data on practices in neural network algorithms and data on the technology of AI influence on environmental performance over some defined specific period within shipbuilding. The cross-sectional design is appropriate for $exploring $, the relationship $between $with $variables$ and associating with each other. This design allows for data collection from a wide range of companies involved in shipbuilding, enabling an examination of the current use of neural network algorithms and AI technology concerning environmental performance across the industry.

To implement the cross-sectional design, researchers will need to identify a representative sample of shipbuilding companies and gather data about their practices of neural network algorithms (e.g., procurement, and manufacturing) and AI technology on environmental performance indicators (e.g., carbon emissions, and waste management). Data have been collected using a questionnaire survey form.

Researchers in the field can benefit from the cross-sectional research design, which enabled the collection of data related to practices of neural network algorithms and the impact of AI technology on environmental performance in the shipbuilding sector, thus providing vital insights into the sustainability landscape in the industry.

Research Population

As for the research population in this case of study (the impact of neural network algorithms on AI technology on Environmental performance in the shipbuilding industry) would be:

Ship Building Department: It consists of the companies engaged in designing, constructing and repairing

the ships. The departments could be diverse in four aspects such as size, type, location, and green supply chain orientation.

Suppliers and subcontractors: These are an aggregation of the suppliers, subcontractors and other stakeholders that make up the shipbuilding supply chain. Such entities help provide materials, components, and services to shipbuilding firms.

Sample Size & Sampling Technique

Based on the topic of the impact of neural network algorithms on AI technology on environmental performance in the ship-building sector in Pakistan, a suitable sampling technique is probability sampling. Probability sampling techniques provide a more rigorous and representative approach to sampling, allowing for the generalization of the findings to the larger population. To get to a 5% error will require a sample of 300+ so for reliable and authentic results more than 300 sample size will be for this research.
The sample will be taken from the designation for filling the questionnaire is classified as below:

- Managers / Deputy Managers / Assistant Managers / Foremen
- Supervisors
- Technicians / Staff
- Suppliers

Research Instrument

For the impact of neural network algorithms on AI technology on environmental performance in the shipbuilding sector in Pakistan, I'll use the following research instruments:

Surveys/Questionnaires: Surveys are commonly used instruments to gather data from participants. Researcher can design a structured questionnaire to collect quantitative data on variables such as the implementation of neural network algorithms practices, AI technology on environmental performance indicators, and perceptions of the effectiveness of green practices in the shipbuilding sector. Researcher will Likert scales, and multiple-choice questions to capture a range of responses.

Observation: Observational methods can be used to gather data on actual practices and behaviours related to neural network algorithms, the role of Green Procurement (GP), Eco-Design (ED), Energy Efficiency (EE), Waste Management (WM) and AI technology on environmental performance (EP) within shipbuilding yards or industries. This can involve directly observing processes, waste management practices, energy usage, and other relevant aspects. Observations can provide valuable qualitative data and help validate self-reported information from surveys or interviews.

Existing Databases: Depending on the availability of relevant databases as shown in Table 2, it can utilize existing data sources related to AI technology on environmental performance indicators, energy usage, waste management, or other relevant variables specific to the shipbuilding sector in Pakistan. This can include government reports, industry databases, or publicly available datasets.

Table 2

Summary of Research Instrument

Variable	No. of items	Scale
Green Procurement	03	1-5
Eco-Design	03	1-5
Waste Management	03	1-5
Energy Efficiency	03	1-5
AI Technology on Environmental Performance	03	1-5

Data Collection

In this study, GP, ED, WM, and EE are independent variables and EP is a dependent variable. Primary sources have been used for data collection and the questionnaire will be according to items which have been taken from the base paper the questionnaire was converted into a Google form, distributed through emails, social media accounts, personal references, and contacts are used to get the desired number of responses for this study.

Data Analyses Method

The data analysis method I'll use is Smart PLS4, applied to incorporate data and it will be collected through the questionnaire of this research PLS are Cronbach's Alpha will be used to test the data and Pearson correlation and Regression hypothetical also will be used and data results are also accumulated in the forms of charts and tables.

Results And Discussions

Table 3 presents the descriptive statistics for 341 respondents, offering a tabulated overview of the frequency and percentage distribution of respondents based on their age, gender, experience, and designation.

Table 3

Demographic data

Respondent Profile		n=341 Frequency	%
Age	18-30	145	42.5%
	31-40	125	36.7%
	41-50	64	18.8%
	51 and above	7	2.1%
Gender	Male	320	93.8%
	Female	21	6.2%
Experience	1-10	214	62.8%
	11-20	96	28.2%
	21-30	26	7.6%
	31 and above	5	1.5%
Designation	Technician	119	34.9%
	Supervisor	90	26.4%
	Supplier	14	4.1%
	Manager	118	34.6%

The assessment of the measurement model's (see figure 2) quality in this research aims to verify its validity and reliability. Data analysis utilized PLS–SEM techniques, employing Smart PLS 4 software for the evaluation.

Figure 2

Measurement Model

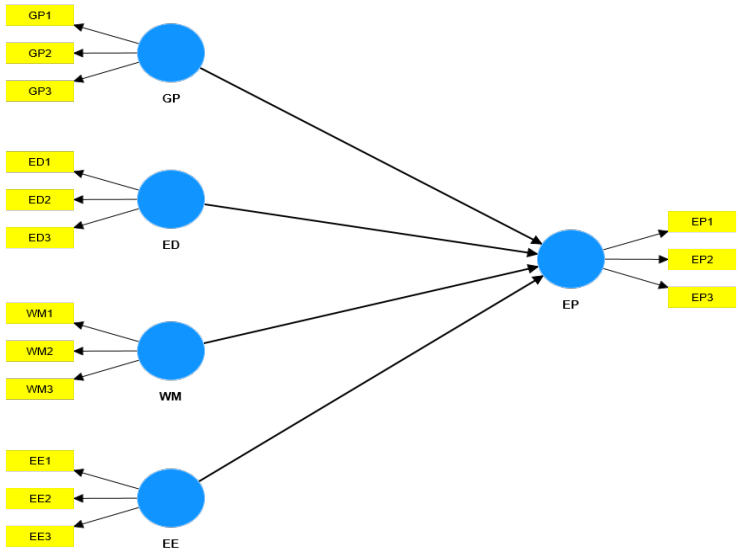


Table 4

Measurement Model

Construct	ITEM	Outer Loading	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	(AVE)
Eco-design	ED1	0.908	0.818	0.843	0.892	0.734
	ED2	0.888				
	ED3	0.767				
Energy efficiency	EE1	0.752	0.732	0.741	0.848	0.651
	EE2	0.829				
	EE3	0.837				
AI technology on environmental performance	EP1	0.841	0.713	0.719	0.84	0.638
	EP2	0.828				
	EP3	0.722				
Green procurement	GP1	0.817	0.769	0.792	0.866	0.684
	GP2	0.884				
	GP3	0.776				
Waste management	WM1	0.810	0.711	0.719	0.838	0.635
	WM2	0.844				
	WM3	0.731				

The study assesses the quality of the measurement model to ensure the validity and reliability of the research. Utilizing PLS–SEM techniques, data analysis was conducted using Smart PLS4 software. The reflective indicator loading signifies that the item effectively measures the latent construct. Following Hulland's (1999) recommendation, reflective indicator loading should exceed or > 0.5. In this study, the reliability analysis results reveal that all items have loadings surpassing 0.5, confirming the reliability of the indicators. Cronbach's alpha serves as a conservative measure assessing the internal consistency and reliability of a set of scale items. The estimated values of Cronbach's alpha gauge the variability in the latent construct, typically recommended to be below 0.7. However, Table 4 indicates that Cronbach's alpha for all constructs surpasses 0.7, signifying that all items exhibit a notably high level of internal consistency.

Convergent reliability is evaluated through the average variance extracted (AVE), with values recommended to be greater than 0.5. In this study, all constructs demonstrate AVE values exceeding 0.5, confirming the convergent reliability of the model. Discriminant validity, assessed through the Fornell-Larcker Criterion, requires that the outer loading of an item within a construct exceeds the cross-loadings of the same item in any other construct. The results, presented in Table 5, confirm that the square root of the average variance extracted (AVE) for each latent variable surpasses its correlation with another latent variable, indicating satisfactory discriminant validity.

Table 5

Discriminant Validity - Fornell-Larcker Criterion

	ED	EE	EP	GP	WM
ED	0.857				
EE	0.383	0.807			
EP	0.378	0.433	0.799		
GP	0.293	0.446	0.311	0.827	
WM	0.412	0.390	0.496	0.237	0.797

Discriminant validity was measured through the Heterotri-Monotrait ratio (HTMT) introduced by (Hasni et al., 2012). This approach calculates the correlation between two latent variables, with a recommended threshold value of 0.90 for Heterotrait-Monotrait (HTMT). The findings, as indicated in Table 6, affirm the presence of discriminant validity validation, as the observed values adhere to the suggested threshold.

Table 6

Discriminant Validity – Hetrotrait Montorait Ratio (HTMT)

	ED	EE	EP	GP	WM
ED					
EE	0.496				
EP	0.432	0.598			
GP	0.352	0.593	0.581		
WM	0.531	0.533	0.574	0.598	

The model's goodness is assessed through the strength of each structural path, gauged by the R-squared (R^2) value for the dependent variable. An R^2 value equal to or exceeding 0.1 is typically considered acceptable. In this study, as depicted in Table 7, the R^2 for AI technology on environmental performance is 0.83, indicating a well-developed predictive capacity for this construct. The outcome signifies an appropriate goodness of fit and reliability of the model.

Table 7

R Square

	R-square	R-square adjusted
Environmental performance	0.832	0.830

The outcomes of hypothesis testing between the dependent and intended variables are presented in Table 8, showcasing the path coefficients obtained through Smart PLS. The structural model underwent analysis using a bootstrap procedure, involving 1000 resampling rounds to enhance the robustness and reliability of the results.

Table 8

Path Analysis

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
ED -> EP	0.377	0.376	0.057	6.655	0.000
EE -> EP	0.057	0.057	0.029	1.976	0.048
GP -> EP	0.352	0.352	0.118	2.988	0.003
WM -> EP	0.190	0.192	0.103	1.840	0.046

This research developed four hypotheses presented in the final study to investigate the significant effect and association of Neural network algorithms approaches and AI technology to the environmental performance of the Pakistan shipbuilding industry. Each hypothesis was tested to determine the relationship between the independent variable and the dependent variable.

The conversation reveals important perspectives on greener practices in Pakistan's shipbuilding industry. These are green procurement, eco-design, and waste management, the key challenge is limited awareness, cost concerns, and regulatory complexities for green procurement. For 4 and 5, changing mindsets, integrating sustainable practices into ongoing processes, and maintaining this over the long run. But the positive effects are not to be overlooked. Such green procurement improves AI technology on environmental performance, as materials are sourced at minimal cost. Eco-design promotes innovation, meets worldwide standards, and lowers costs of operation. Trained on data up to September 2024 Waste management reduces environmental impact, is cost-effective, and meets legal requirements. Combined, such practices promote industry sustainability and are by global standards of eco-friendliness.

The collective effects of AI technology on Environmental Performance (EP) are uncovered directly from descriptions using Green Procurement (GP), Eco-Design (ED), Energy Efficiency (EE), and Waste Management (WM). The interconnected nature of these factors highlights the importance of a comprehensive approach to the implementation of neural network algorithm techniques in the shipbuilding sector.

In the context of shipbuilding, Eco-Design has become an important factor for better AI technology in the area of environmental performance. Results show a large beneficial impact of ED on EP. Eco-Design discusses further how these practices could be integrated as mainstream shipbuilding procedures and identify potential impediments to wide adoption. Eco-design adoption in the shipbuilding industry Eco-design in the shipbuilding sector enhances sustainability with lower environmental impact. It helps to boost innovation, reduces operational costs through energy efficiency, and is tied to global green standards, which greatly helps the long-run work of AI technology on environmental performance.

EE (Energy Efficiency) appears as the most important meta-facilitator that underpins the positive impacts of AI technology on Environmental Performance through shipbuilding. The positive and statistically significant results between EE & EP demonstrate the importance of increasing the energy efficiency of shipbuilding processes. Discuss potential advancements and technologies to improve energy efficiency that may be challenging or cost-prohibitive to implement. Pakistan's shipbuilding industry uses eco-design as a proven method to develop, reduce costs, promote innovations of shipyards in the concept of ship design and ship construction technology, to comply with global demands through international cooperation with ICCT and IMO in the development of its EEDI sea-going vessels, in particular, it promotes the development of sustainability and AI technology to protect the environment.

The positive correlation of Green Procurement on AI technology towards Environmental Performance indicates the same as shown by the results and analysis. This highlights the importance of implementing green procurement practices in the shipbuilding industry instead. However, a lack of awareness and

understanding that is slowing down the adoption of shipbuilding GP green procurement can hinder the successful implementation of GP Green Procurement GP, despite these successful outcomes of GP Green procurement. Resistance to change and the limited availability of environmentally friendly products make the transition harder. Technological governance and risk perception are other hurdles that limit progress. Qualification issues, integration challenges, and reluctance for long-term commitment also make adoption challenging.

The above results and analysis also suggest that Waste Management (WM) practices are directly related to enhancing AI technology on Environmental Performance (EP). It presents innovative waste management approaches relevant to shipbuilding by considering potential obstacles and suggesting waste management improvements. It helps in reducing the negative impact on the environment by preventing the generation of waste and encouraging responsible disposal. There are cost savings associated with optimal utilization of resources and minimizing wastage. Improved adherence to environmental laws enhances the industry's reputation. This generates a long-term influence of AI technology on the environmental performance of shipbuilding in Pakistan, as advancements in waste management enhance the sustainability within the sector and adhere to international environmental norms. It is recommended to use these types of G-PWC like as transacting, customer service and inventory.

The findings of the present study serve as applied knowledge for top management, policymakers and managers to set a base for the promotion of ecological behaviours of their stakeholders (i.e. employees, suppliers, supervisors, managers and government). Neural network algorithms policies and procedures should integrate with an organization if the top management responsible adopts environmental management in the core values of the organization. Top managers play an important role in triggering transformative changes as far as the endorsement of sustainability and AI application to environmental performance is concerned. It has also recommended the preparation of a green procurement policy to enable the purchase of productive services and materials with due consideration for green values. Moreover, periodic in-house green training programs prepare stakeholders to share awareness, knowledge and skills on the aforementioned sub-factors, including waste management, electronic data filing, energy optimization, green technology, emissions- and waste-reduction, recycling which can reduce an employee's carbon footprint and enhance employees' green behaviour towards the organization.

These findings have implications for shipbuilding companies or yards that aim to improve their environmental performance through the development of their AI technology. The paper concludes with practical recommendations for policymaking that would support the broader adoption of neural network algorithm practices across companies. This climate change issue is another example of how environmental considerations are becoming critical factors in the multifactorial success of commercial organizations and the overall well-being of the environment, and the statism of state regulations may have a more profound effect on their conduct.

This will promote awareness of green practices and incentives for their adoption to facilitate adopting solutions to encountering challenges in the shipbuilding of Pakistan. Set up training schemes for eco-design integration and provide research funding for environmentally friendly tech. Promote technology adoption for energy-efficient technologies and facilitate interaction between the industry and technology providers. Promote educational programs for proper waste management and sustainable policies. Encourage platforms to share knowledge and include sustainability in corporate agenda Encourage collaborations for sustainable projects and research new technologies. Perform lifecycle analyses, define performance monitoring systems, and enable continuous improvement through feedback loops and best practice comparisons.

The study has several limitations that affect the breadth and generalizability of its findings. For instance, the particularity of the research is being focused on one specific industry (shipbuilding in Pakistan) hence, the findings may not be directly relevant or applicable to organisations operating in different

industries or geographical locations. The limitation comes from available data since this study is high only if the data are available and correct at the time of processing. Interviews often provide qualitative insights, which could limit the subjectivity of information obtained by biasing certain findings. Resource Constraints: The availability of resources can limit the study's depth and breadth, affecting the comprehensiveness of data collection and analysis. Such limitations raise questions for future studies contributing to possible directions of the shipbuilding industry towards sustainability.

In doing so, it contributes to knowledge within the shipbuilding sector in Pakistan and potentially guides future direction and strategic decisions. The shipbuilding industry is dynamic and changes in regulations, technologies, or market conditions that occur after the study may affect the relevance and applicability of the findings. While these approaches help extract qualitative and subjective data, they also leave room for response bias, wherein participants might provide socially desirable responses, as opposed to fully honest interaction. The cross-sectional design of the study represents a snapshot not a longitudinal analysis of trends over time; dynamic changes within the industry may be overlooked.

This study provides evidence and revelations regarding the dynamic nature of the above-mentioned practices, under the complex nature of artificial intelligence factors (Neural network algorithms) and their overall impact on the Environmental Performance aspect of this study in the context of the Pakistan shipbuilding industry. Based on the research findings, all four independent variables of Green Procurement (GP), Eco-Design (ED), Energy Efficiency (EE), and Waste Management (WM) positively impacted AI technology on the Environmental Performance (EP). The discoveries emphasize the significant impact of neural network algorithm utilization practices on the environmental performance of Pakistan's shipbuilding industry. This enhances the current literature with practical implications for academics and policymakers, as well as potential implications for academic researchers. This research promotes a holistic perspective, which is consistent with the growing acknowledgement by the industry that sustainable practices are needed. These limitations should be addressed, and explore more detailed aspects of the neural network algorithm of shipbuilding through future research.

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