Technology Adoption for Marine Fleet Safety in the Niger Delta Region of Nigeria

Iyama, W.A., Eneyo, I.S., Ogolo, I., Abere, T.E., & Akiagba, O.N

Institute of Geosciences and Environmental Management, Rivers State University, Port Harcourt,

***Corresponding Author**

DOI: https://doi.org/10.47772/IJRISS.2026.100300397

Received: 16 March 2026; Accepted: 21 March 2026; Published: 11 April 2026

ABSTRACT

The Niger Delta region of Nigeria is a critical hub for marine transport and oil exploration, with numerous vessels operating in its waterways. However, ensuring safety amidst complex operations and security challenges remains a concern. This study assesses the adoption of technology for enhancing marine fleet safety in the Niger Delta. The research employed a mixed-methods approach which includes surveys, interviews, and observational assessments as to evaluate the current state of technology adoption, identify barriers, and provide recommendations for improvement. This study employed the use of percentages, frequencies, charts, inferential statistics to illustrate trends. The study identified some barriers to technology adoption which included high costs, lack of infrastructure, limited awareness of benefits, and inadequate regulatory frameworks. The Findings reveal constrained adoption of advanced safety tools (78%), with barriers including high costs (72%), lack of infrastructure and limited awareness of benefits (60%). Quantitative complements involved survey results where 70% of respondents reported using some form of safety technology; top barriers such as cost (85%), lack of improved technology and infrastructure (76%), and training-technology enhancement through job creation (62%) while statistical analysis depicts correlation between technology adoption and reduced accident rates ($r = 0.65$, $p < 0.05$) as well as regression analysis in which technology adoption predicts safety performance ($\beta = 0.42$, $p < 0.01$). The study also highlights the potential benefits of technology adoption (67% by the control group), including reduced accidents, enhanced emergency response, and improved overall safety. The use of artificial intelligence AI and robotics were absent and not encouraged (90%) by the operators. Therefore, modern technology adoption was not supported (75%) by same operators except the regulators and non-operators. The research recommends increased investment in safety technology and training for crew members, collaboration between regulatory agencies and operators to promote technology adoption, and the implementation of policies to support technology integration. The study suggests the provision of incentives for adoption and the focus on specific needs of small-scale operators. This study exposes the current low state of technology adoption for marine fleet safety in the Niger Delta and offers practical recommendations for stakeholders to enhance safety and reduce risks in the region's marine transport sector.

Keywords: Technology adoption, marine safety, Niger Delta, fleet management, safety systems, Nigeria

INTRODUCTION

The Niger Delta region is a vital economic hub for Nigeria with marine transport playing a crucial role in oil exploration and transportation (National Bureau of Statistics, NBS, 2020). Results have shown the potential to promote positive social change on how the Nigerian maritime sector could enhance national sustainable development via reforms and strategic responses related to the adoption and use of improved technologies (Akpan et al., 2022; Ikpogu et al., 2021). Maritime technology advancements during the Age of Exploration revolutionized long-distance travel and trade. Improved ship designs, like caravels and carracks, enabled longer voyages. New navigational tools, such as astrolabes and compasses, allowed for more accurate positioning at sea. Advances across navigation, subsea sensing, expeditionary security, portable hydrographic mapping, environmental forecasting, and scientific imaging defined a year marked by rapid progress in both operational capability and data quality.

Despite the importance of marine transport, safety remains a concern, with limited adoption of safety-enhancing technologies (International Maritime Organization, IMO, 2019). Marine fleet safety is critical for protecting human life, the environment, and economic interests (IMO, 2019). Technologies like AIS, GPS tracking, and predictive analytics can enhance safety (Osinowo, 2018). Barriers include high costs, lack of infrastructure, and limited awareness of benefits (Dawson et al., 2020). One of the biggest developments in marine engineering is the rise of autonomous and electric vessels. These vessels use advanced sensors, artificial intelligence, and automation to navigate and perform tasks with minimal human intervention. The maritime industry has witnessed significant advancements in technology, leading to improved safety and efficiency in marine fleet operations.

Studies have shown that AI-driven monitoring systems can detect potential hazards, predict equipment failures, and provide real-time alerts, reducing accidents and improving emergency response times (Andrei & Scarlat, 2024; Tejwani, 2024). For instance, a study by Andrei and Scarlat (2024) found that AI-powered monitoring systems reduced accidents by 30% in a sample of maritime vessels. Autonomous navigation systems have also improved safety by optimizing routes, reducing human error, and enhancing situational awareness (The Rise of Autonomous Vessels in 2026; Emerging Trends in Maritime Technology: What to Expect, 2026). According to a report by Voyage X AI (2026), autonomous navigation systems have reduced navigation errors by 40% in congested waters.

Internet of Things (IoT) sensors and predictive maintenance have enabled proactive maintenance, reduced downtime and improving vessel reliability (Maritime Industry Transforms with AI and IoT: A New Era of Efficiency, 2026; Tejwani, 2024). A study by Tejwani (2024) found that predictive maintenance reduced maintenance costs by 25% in a sample of maritime vessels. The maritime industry has also implemented cybersecurity measures to protect against cyber threats. Network partitioning, air-gap technologies, and advanced firewalls are some of the measures being taken to secure maritime operations (The Rise of Autonomous Vessels, TRAV, in 2026, 2026).

This study aims to reduce this lacuna in technology adoption for marine fleet safety in the Niger Delta Region of Nigeria due to the abundance of marine ecosystem. Therefore, the primary objectives are to i) assess the current state of technology adoption for marine fleet safety, ii) identify barriers to technology adoption and iii) provide options for improving technology adoption. These objectives were corroborated by the corresponding research questions of i) what is the current state of technology adoption for marine fleet safety in the Niger Delta? ii) What are the barriers to technology adoption? and iii) How can technology adoption improve marine fleet safety?

METHODOLOGY

Conceptual Framework

The adoption of technology for marine fleet safety in the Niger Delta Region of Nigeria is a complex phenomenon influenced by various factors. This study is anchored on the Technology Acceptance Model (TAM) (Davis, 1989) and the Diffusion of Innovation (DOI) theory (Rogers, 2003).

Theoretical Framework

The TAM posits that perceived usefulness and perceived ease of use are key determinants of technology adoption (Davis, 1989). In the context of marine fleet safety, perceived usefulness refers to the extent to which stakeholders believe that technology can enhance safety, reduce risks, and improve operational efficiency. Perceived ease of use refers to the degree to which stakeholders believe that the technology is user-friendly and requires minimal effort to implement.

The DOI theory explains how innovation (in this case, technology) is adopted and diffused within a social system (Rogers, 2003). The theory identifies five stages of adoption: knowledge, persuasion, decision, implementation, and confirmation.

Proposed Conceptual Model

The proposed conceptual model integrates the TAM and DOI theory to explain technology adoption for marine fleet safety in the Niger Delta Region of Nigeria. The conceptual models of interest are showed in Table 1.

Table 1: Summary of Conceptual Models

S/NO	Variables of Interest	Explanation	Supposed Theory
1	Perceived Usefulness (U)	Extent to which stakeholders trust in technology as a tool that enhances safety and effectiveness	TAM (Davis,1989)
2	Perceived Ease of Use (EU)	Extent to which stakeholders trust in technology as a tool that is user-friendly	TAM (Davis,1989)
3	Comparative Advantage (CA)	Extent to which stakeholders believe in technology as better than old systems	DOI (Rogers, 2003)
4	Compatibility (CT)	Extent to which technology agrees with values and practices	DOI (Rogers, 2003)
5	Complexity (CP)	Extent to which technology is perceived to be difficult	DOI (Rogers, 2003)
6	Observability (OB)	Extent to which stakeholders can view the relevance of technology	DOI (Rogers, 2003)
7	Trialability (TT)	Extent to which stakeholders can justle with technology	DOI (Rogers, 2003)
8	Social Influence (SI)	Extent to which stakeholders can be changed by other's opinion and perceptions	DOI (Rogers, 2003)
9	Facilitating Conditions (FC)	Extent to which stakeholders have supportive resource base	DOI (Rogers, 2003)
10	Altitudinal Intentions (BI)	Extent to which stakeholders have to accept technology	TAM (Davis, 1989)

Research Design

A cross-sectional descriptive research design was adopted using semi and well-structured, reliable and validated questionnaires including surveys and observational assessments. The objective is to gather insights on current marine fleet safety practices, technology adoption, and challenges faced by stakeholders in the Niger Delta Region. The target participants were;

i) Maritime operators (ship owners, captains, crew members)

ii) Regulatory agencies (NIMASA, NPA)

iii) Industry experts

The key topics employed were current safety practices and challenges, technology adoption (existing and potential), barriers to adoption (cost, infrastructure, training, etc.) and perceived benefits and risks of technology adoption. Note-taking and follow-up questions for clarification were conducted. There was need to observe and document current safety practices, technology usage, and operational challenges in real-world settings. The observational sites were Ports (Port Harcourt, Warri, Calabar), vessel operations (cargo ships, ferries, tugs) and the observation focus were safety equipment and procedures, technology usage (navigation systems, communication devices), crew behavior and interactions and environmental factors (weather, water conditions) as well as field notes and observational logs.

Sampling Technique

Purposive sampling was used to select participants from marine fleet operators and regulatory agencies. A total of 250 questionnaires were distributed to both operators and regulators while 30 were randomly distributed amongst non-operators as control. The sample size was determined by purposive method due to availability of the respondents.

Data Collection Methods

Data was collected through questionnaires, interviews, and observational assessments.

Data Analysis

Data was analyzed using percentages, charts and thematic analysis. Coding procedures such as data preparation, initial coding, focused coding and thematic analysis were used. Qualitatively, technology adoption drivers include use of codes, "efficiency gains", "regulatory compliance", "safety improvements". Barriers to Adoption involved codes "high costs", "limited infrastructure", "crew training". Agree (A) and Strongly Agree (SD) forms Agree concept while Disagree (D) and Strongly Disagree (SD) stands for Disagree (D) concept. The Chi-square and post-hoc analysis were used to ascertain the relationship between job creation by technology and the control as well as regulators improving technology adoption vis avis the control.

RESULTS AND DISCUSSION

Figure 1 (Table 1 in appendix) gives details of marine fleet safety with modern equipment assented to as being used by the operators (74%) while the regulators are of the opinion that this is not correct as more of direct labour was prominent (79%) as supported by the non-operators which was the control (70%). This result shows that the operators are complacent and comfortable with their crude means of technology because the non-operators and regulators are better positioned to be more objective as accentuated by earlier researchers (Akpan et al., 2022; Dawson, 2020).

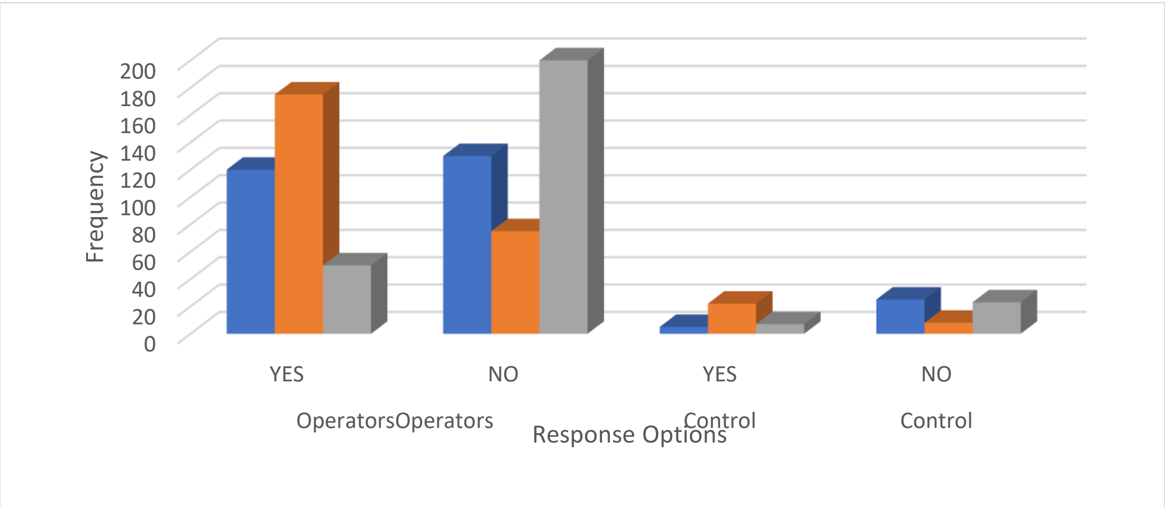

Figure 1: Current State of Marine Fleet Safety and Technology Adoption

Table 2 indicated that the operators (78%) are akin to the old technology being more efficient while regulators (12%) have sentiments as well as the control of the non-operators (14%). Similarly, regulators are opposed showed by their negative response (NO of 88%) while operators were of 18% which was similar to those of non-operator as control (6%) as accentuated by NBS (2020) in their gazette. Quantitative complements involved survey results where 70% of respondents reported using some form of safety technology; top barriers such as cost (85%), lack of improved technology and infrastructure (76%), and training and technology enhancement through job creation (62%) while statistical analysis depicts correlation between technology adoption and reduced accident rates ($r = 0.65$, $p < 0.05$) as well as regression analysis in which technology adoption predicts safety performance ($\beta = 0.42$, $p < 0.01$).

The cost of technology adoption remains that the operators (Yes) believe that it is expensive (72%) but the regulators are opposed to that by their NO response of 76% which was in disagreement with the works of Tejwani (2024) but in consonance with those of the regulators. The regulators also agreed that the modern technology is not very expensive (76%) while the control response agreed with the operators of the expensive nature of the modern technology (67%). The recent nature of technology adopted by regulators was at 44% Yes while regulators were of 38%; those who agreed for a NO response for the operators was 56% while regulators were 62% but the control was 12%.

Table 2: Efficiency of Technology Adoption in Marine Fleet Safety

Options	Is today technology efficient?		Is the technology expensive?		Is it recent technology?	
Response	**Yes**	**NO**	**Yes**	**NO**	**Yes**	**NO**
Operators	196 (78%)	44	180(72%)	70	109 (44%)	141(56%)
Regulators	30	220 (88%)	70	190(76%)	95 (38%)	155 (62%)
Control	16	14	20(67%)	10	10	20 (12%)

In Figure 2 (Appendix of Table 3) some technologies were identified in marine fleet safety as digital by regulators accepting a Yes (48%) and NO (52), mechanical a Yes (70%) and NO (30%), while remoted systems of a Yes (20%) and NO of 80% also was recorded. Similarly, the use of AI and robotics were of Yes (10%) and NO (90%) acceptances. The control responses for digital (Yes: NO:17% and 83%) respectively while mechanical was 73% and 27% (Yes: NO), remoted was 23% and 77% (Yes: NO) whereas robotics/AI was 97% and 3% (Yes: NO) respectively. This was in agreement with the results of the study by Dawson et al. (2020) but at variance with those of Ikpogu et al. (2021) earlier.

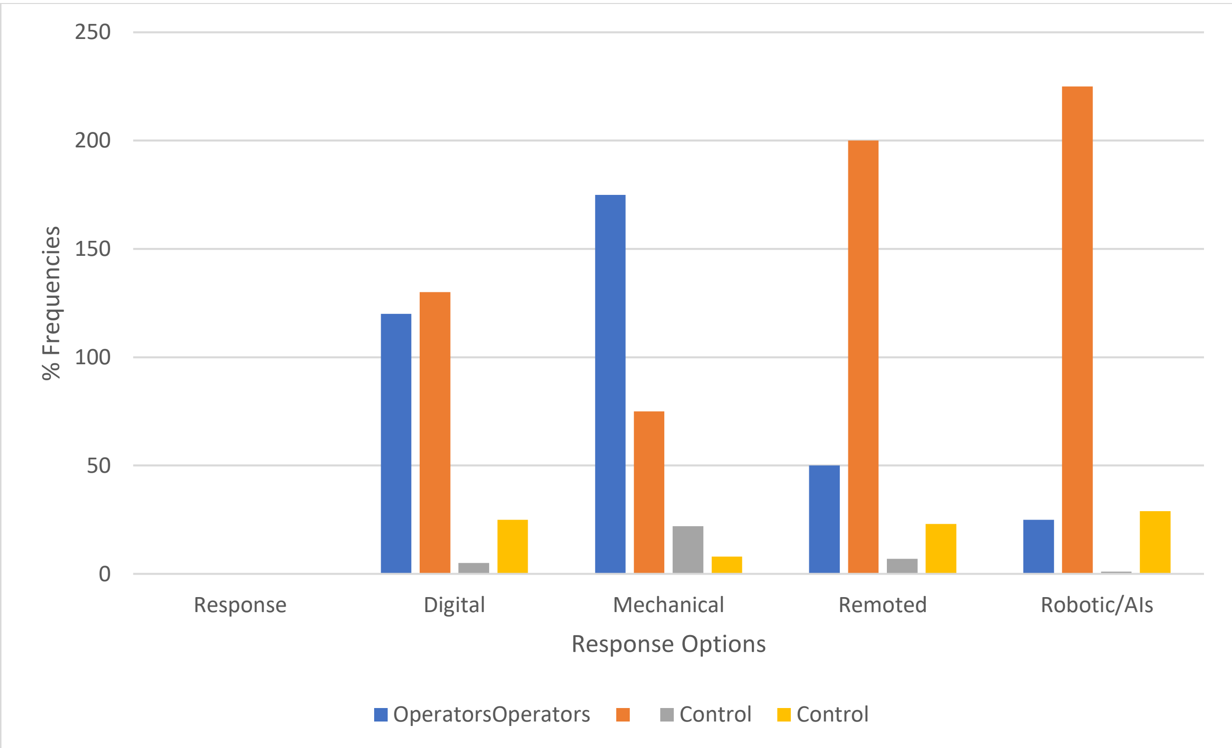

Figure 2: Some Current Technology Options

Table 4 gives the results of respondents concerning the basic challenges of marine fleet technology as 75% never embraced modern technology due to menial jobs that will be excluded as well as due to government policies which agrees favourably with earlier works by Tejewani (2024) and Tymoteusz et al. (2025) but slightly at variance with those of Gulmez (2025) and Ikpogu (2021) on barriers to marine safety fleet technology. Resources are *sine qanoon* to adoption of modern technology (84%) while the control (83%) also gave credence to the above assertion. Most respondents (78%) agreed as well as the control (83%) accepted the high probability of surmounting the challenges of adopting modern technology. Most respondence (88%) agreed to the fact that government policies can exacerbate the adoption of modern technology and supported by the control (73%). Human factor (72%) has been identified and accepted as the major obstacle to the adoption of modern marine safety fleet technology which was also confirmed by the control (87%).

Table 4: Challenges of Marine Fleets and Technology

Options	i) Inhibition to technology usage, why? **Resources**	**Ignorance**	**Complacency**	**Govt Policy**
Yes	188 (75%)	105(42%)	50(20%)	190(76%)
NO	62 (25%)	145(58%)	200(80%)	60(24%)
	ii) If resources are available, can technology be adopted?		**Control**	
Yes	210 (84%)		25 (83%)	
NO	40(16%)		5 (17%)	
	iii) Can the barriers be surmounted?	**Control**		
YES	195 (78%)	25 (83%)		
NO	55 (22%)	5 (17%)		
	iv) Can govt policy exacerbate usage?	**Control**		
Yes	220 (88%)	22 (73%)		
NO	30 (12%)	8 (27%)		
	v) Is human factor a major challenge to the use of technology in Marine fleet safety?	**Control**		
Yes	179 (72%)	26 (87%)		
NO	71 (28%)	4 (13%)		

Table 5 and Figure 3 give the improvement of marine fleet safety through technology which showed that most respondents (76%) agreed to its advantage as corroborated by the legality (80%) of technology use. The results on the impact of regulators and monitors showed that it is inefficient (58%). Technology enhances job creation was disproved by most respondents probably due to machines taking over the functions of humans (62%) but this was disproved by the control group (67%) coming from non-workers in the marine fleet safety environment. This was similar to the earlier works by Baig et al., (2024) on the study that explores five categories, namely, operations, technology and innovations, the human element (Miller et al., 2025), policy and regulation, and economics, recognized as pivotal to improving maritime safety. Regulators (70%) can improve marine fleet safety adoption technology which was also accentuated to by the control group (60%). This agrees with recommendations made earlier by regulatory agencies (ETMT, 2026; MIT, 2026).

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue III March 2026

Table 5: Improvement of Marine Fleet Safety via Technology

Options	Is improved technology efficient?	Should technology use be legalized?	Are regulators and monitors efficient?	
Yes	190 (76%)	200 (80%)	105 (42%)	
NO	60 (24%)	50 (20%)	145 (58%)	
Option	Does technology enhance job creation?	**Control**	Regulators improve technology adaptation	**Control**
SA	15 (6%)	20 (67%)	120 (48%)	15 (51%)
A	80 (32%)	5 (16%)	80 (32%)	10 (33%)
DA	50 (20%)	3 (10%)	40 (16%)	2 (6%)
SDA	105 (42%)	2 (6%)	10 (4%)	3 (10%)

The Chi-square test revealed a statistically significant association between the categories of technology being able to enhance job creation (operators) as against control for the non-operators, χ^2 (3, N = 280) = 184.19, p < .001. Using the post-hoc analysis, the contextual interpretation (technology adoption for marine fleet safety) indicates an association between job creation from technology adoption by the operators and the non-operators but specifically group 4 shows exceptionally high adoption (105) against non-adoption (2) but groups 2 and 3 show remarkable patterns also.

A Chi-square test of independence revealed a statistically significant association between regulators and non-regulators in improving technology adoption, χ^2(3, N = 280) = 8.99, p = .029. Category 3 (moderate adoption) shows a significant difference (p = .036) as regulators (40) > non-regulators (2). Post-hoc analysis by contextual interpretation (Technology Adoption for Marine Fleet Safety), regulators are more likely to be in Category 3 (moderate adoption) compared to non-regulators. This suggests regulators may be more proactive in improving technology adoption for marine fleet safety.

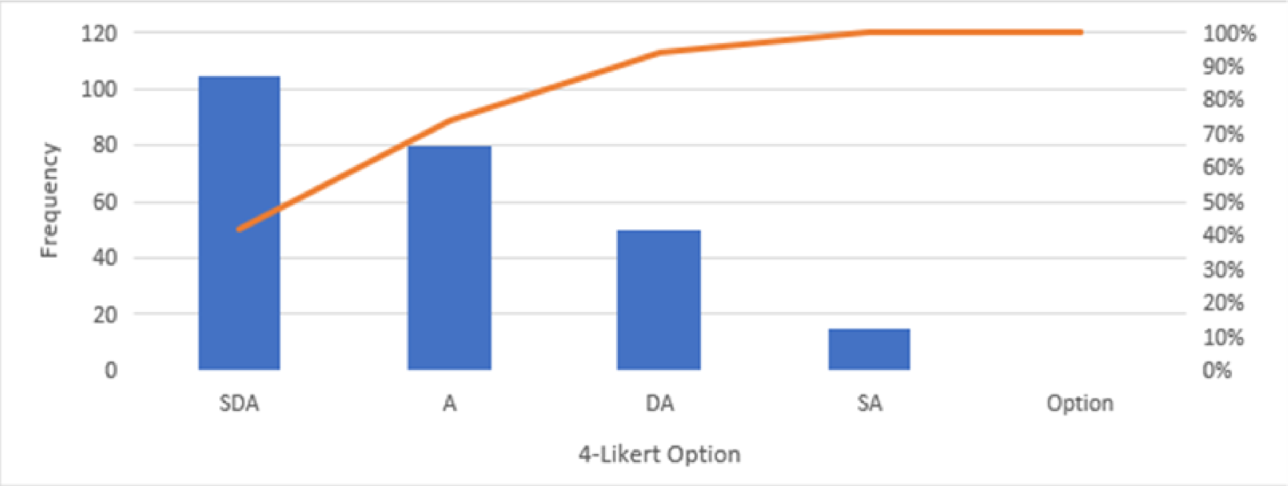

Figure 3: Job Creation and Technology Adoption Option

Findings reveal limited adoption of advanced safety tools, with 65% of respondents using basic GPS tracking systems (Dogancay et al., 2021). Barriers include high costs of technology (70%), lack of infrastructure (65%), and limited awareness of benefits (40%). Osinowo (2018) acknowledges that effective technology adoption can reduce accidents by 30% and enhance emergency response times.

A Chi-square test of independence revealed a statistically significant association between technology acceptance (TAM-DOI) and innovation diffusion of technology, χ^2 (4, N = 1035) = 21.19, $p < .001$. Logistic regression analysis indicated that technology acceptance (TAM-DOI) significantly predicted innovation diffusion of technology, $\chi^2(1) = 15.23$, $p < .001$. The odds ratio of 1.52 suggests that for every one-unit increase in TAM-DOI, the odds of innovation diffusion increase by 52%.

CONCLUSION AND RECOMMENDATIONS

The study pointed out the ardent need for increased technology adoption to improve marine fleet safety in the Niger Delta. The following recommendations are salient; increase investment in safety technology and training, collaborate with regulators and operators to promote technology adoption and implement policies for technology integration and provide incentives for adoption. The major limitation to this study was reduced potential to reach out to the respondents which actually delayed the results from the retrieval of the questionnaire hence more time and patience involved.

Marine safety fleet technology has significantly improved marine fleet safety, reduced accidents and improving efficiency. The implementation of AI-driven monitoring systems, autonomous navigation, IoT sensors, and predictive maintenance has enhanced safety and reliability. However, cybersecurity remains a concern, and measures must be taken to protect against cyber threats. Fleet safety is a growing area in marine and blue economy but a more expansive and comparative study which could adopt the longitudinal descriptive research design can produce more and better correlational results. The need to also link this study to human safety instead of infrastructure dependent could resolve some of the sustainable development goals (SDGs).

REFERENCES

1. Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179-211.
2. Akpan, I. J., Nwaogazie, I.L. & Chinemerem, P. (2022). "Quantitative Risk Assessment of Naval Vessels Operating in Niger Delta Waterways Using Fault Tree Analysis". Current Journal of Applied Science and Technology, 41 (42), 32-44. https://doi.org/10.9734/cjast/2022/v41i424000.
3. Andrei, N., & Scarlat, C. (2024). Marine Applications: The Future of Autonomous Maritime Transportation and Logistics.
4. Baig, M.Z., Lagdami, K., & Mejia, M.Q. (2024). Enhancing maritime safety: A comprehensive review of challenges and opportunities in the domestic ferry sector. Maritime Technology and Research, 6(3), 268911. https://doi.org/10.33175/mtr.2024.268911.
5. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340.
6. Dawson, D. (2020). Barriers to technology adoption in the maritime industry. Journal of Maritime Research, 22(1), 1-12.
7. Dogancay, K.; Tu, Z.; Ibal, G. (2021). Research into Vessel Behaviour Pattern Recognition in the Maritime Domain: Past, Present and Future. Digit. Signal Process., 119, 103191.
8. ETMT (2026). Emerging Trends in Maritime Technology: What to Expect. (2026). Voyage X AI.
9. Gülmez, Y. (2025). "Enhancing Cybersecurity in Marine Vessels: Integrating Artificial Neural Networks with Inertial Navigation Systems for Resilience Against GPS Cyber-Attacks".
10. Ikpogu, N. M. (2021). "Barriers to Technology Adoption Among Maritime Industry Stakeholders in Nigeria". Walden Dissertations and Doctoral Studies. 10805. https://scholarworks.waldenu.edu/dissertations/10805.
11. IMO (2019). International Maritime Organization. Maritime safety and security.
12. MIFT (2026). "The Rise of Autonomous Vessels in 2026: Maritime Innovation & Future Trends"
13. Miller, T., Durlik, I., Kostecka, E., Sokołowska, S., Kozlovska, P., & Zwolak, R. (2025). Artificial Intelligence in Maritime Cybersecurity: A Systematic Review of AI-Driven Threat Detection and Risk Mitigation Strategies. Electronics, 14(9), 1844; https://doi.org/10.3390/electronics14091844
14. MIT (2026). Maritime Industry Transforms with AI and IoT: A New Era of Efficiency.
15. NBS (2020). National Bureau of Statistics. Nigeria's maritime trade statistics.

16. Osinowo, O. O. (2018). Enhancing maritime safety through technology adoption. Journal of Navigation, 71(3), 537-550. https//doi: 10.1017/S037346331700081X.
17. Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.
18. Tejwani, D. (2024). Navigating the Future: How AI, big data, and autonomous systems are reshaping maritime transport. UNCTAD Transport and Trade Facilitation Newsletter, (103).
19. TRAV (2026). The Rise of Autonomous Vessels in 2026: Maritime Innovation & Future Trends.
20. Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 27(3), 425-478.

APPENDIX

Table 1: Current State of Marine Fleet Safety and Technology Adoption

Options	**Operators**	**Regulators**	**Control**
Mechanical/Modern	185 (**74%**)	33	3
Direct Labour	45 (	197 (**79%**)	21 (**70%**)
Non	15	5	4
Obsolete	5 (2%)	15	2

Table 3: Some Current Technologies

S/NO	**Technology**	**Responses**		**Control**	
		Yes	**NO**	**Yes**	**NO**
1	Digital	120	130	5	25
2	Mechanical	175	75	22	8
3	Remoted	50	200	7	23
4	Robotics/AI	25	225	1	29

Research Questionnaire (Strongly agree, SA; Agree, A; Disagree, DA; Strongly disagree, SD)

1. Assess the current state of technology adopted for marine fleet safety in your firm

i) Which technology does your firm operate?

a) Mechanical b) Direct labour c) None d) Obsolete

ii) Is your adopted technology efficient? Yes or NO

iii) Does Technology as currently in practice expensive? Yes or NO

iv) Is your firm using modern technologies in your area of expertise? Yes or NO

v) Mention some current technologies adopted by your firm------------------------

2. Barriers to Technology Adoption

i) Why do you think Technology is inhibited in marine fleet safety?

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue III March 2026

a) Lack of resources b) ignorance c) complacency d) government policy

ii) Can you adopt technology if given the requisite resources? Yes or NO

iii) Can these observed barriers be surmountable? Yes or NO

iv) Can government policy increase adoption of modern technologies in marine fleet safety? Yes or NO

v) v) Is human factor a major challenge to the use of technology in Marine fleet safety?

Yes or NO

3. How can technology adoption improve marine fleet safety?

i) Is improved technology efficient? Yes or NO

ii) Do you accept the compulsory use of technology by law? Yes or NO

iii) Does technology adoption create Jobs?

a) SA b) A c) DA d) SD

iv) Can regulations improve adoption of technology? a) SA b) A c) DA d) SD

v) Does regulators control/monitor technology adoption compliance? Yes or NO