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INSTITUTIONAL READINESS, IMPLEMENTATION CHALLENGES, AND STRATEGIC POLICY FRAMEWORKS FOR AI-DRIVEN CUSTOMS MODERNIZATION IN NIGERIA

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Abstract

This study quantitatively examined institutional readiness, implementation challenges, and strategic policy frameworks for Artificial Intelligence (AI)-driven customs modernization within the Nigeria Customs Service. A descriptive survey design was employed, with data collected from approximately 500–600 customs officers selected through stratified random sampling. Structured questionnaires measured technical, organizational, and regulatory challenges, officer readiness, and policy strategy preferences using a five-point Likert scale. Data were analyzed using descriptive statistics (frequencies, means, and standard deviations). Findings reveal a moderate level of implementation challenges (Grand Mean = 2.92), with the most significant constraints being lack of skilled personnel (Mean = 3.03), budget limitations (Mean = 3.02), and insufficient technical infrastructure (Mean = 2.99). Officer and stakeholder readiness was also moderate (Grand Mean = 2.72), although gaps were observed in training adequacy (Mean = 2.48) and digital literacy program implementation (Mean = 2.43). Conversely, there was strong agreement on strategic interventions required for AI integration (Grand Mean = 3.16), particularly in training and capacity building (Mean = 3.27), legal/ethical frameworks (Mean = 3.23), and structured policy development (Mean = 3.19). The study concludes that while institutional momentum toward AI adoption exists, successful implementation is constrained by human, technical, and regulatory deficits. However, strong stakeholder support for structured reforms indicates high potential for scalable AI integration if policy and capacity gaps are addressed.

Keywords:

Artificial Intelligence, Customs Modernization, Institutional Readiness, Policy Framework, Nigeria Customs Service.

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1.0 Introduction

The rapid infiltration of artificial intelligence (AI) into governmental and border-management architectures has radically disrupted traditional customs administration, transforming what were once sluggish bureaucratic machines into technologically fortified systems aimed at suppressing inefficiency, minimising corruption, and accelerating trade facilitation. Across advanced economies, customs institutions have increasingly embraced AI-powered frameworks such as predictive analytics, automated risk profiling, blockchain-enabled compliance systems, and intelligent surveillance technologies to dismantle obsolete administrative structures that previously functioned as parasitic bottlenecks on global commerce (World Customs Organization [WCO], 2022; Besson & Rowe, 2023). These innovations are not merely cosmetic technological embellishments but strategic institutional weapons designed to exterminate procedural redundancy, strengthen transparency, and fortify national competitiveness in an increasingly digitised global trade environment. Consequently, customs modernisation has become an unavoidable imperative for states seeking to avoid institutional obsolescence in the face of rapidly evolving international trade systems.

In developing economies, particularly within Africa, the deployment of AI in customs administration remains comparatively uneven, constrained by structural deficiencies, policy incoherence, weak digital ecosystems, and deeply entrenched bureaucratic inertia. Scholars such as Mutambara and Moeti (2022) argue that many African customs institutions continue to function as administratively fossilised entities, trapped within fragmented digital systems, low institutional readiness, and policy paralysis that collectively undermine efficient trade governance. This stagnation perpetuates systemic inefficiencies, breeds regulatory opacity, and exposes customs institutions to exploitative practices that drain national revenues and obstruct regional trade competitiveness. While nations such as Rwanda, Kenya, and South Africa have demonstrated increasing institutional appetite for AI-enabled customs transformation through targeted policy reforms and digital capacity building, Nigeria's progress remains substantially more fragmented and structurally vulnerable (Wanjiku & Moyi, 2021; Nabukenya, 2023).

The Nigeria Customs Service (NCS), as a principal organ of national revenue mobilisation, border enforcement, and trade regulation, occupies a strategically critical yet operationally burdened position within Nigeria's economic architecture. Despite multiple reform initiatives including the Nigeria Integrated Customs Information System (NICIS II), the Trade Modernisation Project, and broader digitalisation campaigns, empirical assessments reveal that NCS continues to grapple with technological insufficiencies, weak staff digital literacy, policy inconsistency, and substantial implementation bottlenecks (Mohammed & Adamu, 2023; Obadiah et al., 2025). These persistent vulnerabilities suggest that the institution's transition towards AI-driven customs administration remains hindered by deeper organisational, technical, and regulatory dysfunctions rather than mere technological scarcity. The bureaucratic machinery, in many respects, continues to exhibit characteristics of administrative resistance and structural fragility, thereby limiting the transformative capacity of emerging AI technologies.

Institutional readiness constitutes one of the most decisive determinants of successful AI integration, particularly within public-sector environments where technological adoption frequently collides with entrenched organisational cultures, workforce limitations, and governance deficits. Readiness encompasses digital literacy, technical competencies,

leadership commitment, organisational flexibility, and stakeholder confidence in emerging systems (Akomolehin & Akomolehin, 2026). In the absence of these foundational capacities, AI systems risk becoming hollow symbolic artefacts rather than substantive instruments of institutional transformation. Nigerian public institutions have historically struggled with low digital preparedness, infrastructural inadequacies, and resistance to innovation, factors which may severely compromise the practical integration of AI within NCS operations (Oseni, 2024). Therefore, evaluating the readiness of customs officers and institutional stakeholders is indispensable for understanding whether AI modernisation can transcend policy rhetoric and materialise into operational reality.

Beyond readiness, the implementation of AI within customs administration is further constrained by technical, organisational, and regulatory barriers that often function as systemic predators against innovation. Technical constraints such as poor interoperability, cybersecurity weaknesses, fragmented databases, and insufficient infrastructure continue to undermine AI deployment in many developing contexts (Okoro et al., 2026). Organisational barriers, including workforce resistance, inadequate training, and bureaucratic conservatism, exacerbate implementation fragility, while regulatory deficiencies create legal ambiguity regarding data governance, ethical oversight, and accountability structures. These intersecting constraints frequently transform promising technological reforms into policy carcasses incapable of delivering substantive governance improvements.

Sustainable AI integration within customs institutions necessitates coherent strategic frameworks and robust policy architectures capable of aligning technology deployment with governance priorities. Effective policy structures must address institutional capacity building, digital governance, legal reforms, stakeholder engagement, and inter-agency collaboration. Without such strategic coherence, AI adoption risks devolving into fragmented experimentation devoid of lasting institutional impact (Oludi, 2026). For Nigeria, where customs inefficiency imposes severe economic costs through trade delays, compliance failures, and revenue leakages, the development of practical AI integration strategies is essential not only for operational enhancement but for broader national economic resilience.

Despite increasing discourse surrounding digital governance and AI adoption, there remains a substantial empirical vacuum regarding the specific readiness, implementation barriers, and strategic pathways for AI integration within the Nigeria Customs Service. Existing scholarship has largely concentrated on general automation or public-sector digitalisation while neglecting the nuanced institutional dynamics that shape AI modernisation in customs administration (Obadiah et al., 2025). This scholarly deficit limits evidence-based policymaking and weakens the intellectual foundations necessary for meaningful customs reform. Against this backdrop, this study investigates the major technical, organisational, and regulatory challenges affecting AI implementation in Nigeria Customs Service operations, examines the readiness, digital literacy, and perceptions of NCS officers and relevant stakeholders, and proposes strategic policy recommendations for the effective integration of AI into customs governance.

2.0 Statement of the Problem

The global diffusion of artificial intelligence (AI) in customs administration has intensified expectations for governments to transform their border management systems into efficient, transparent, and technologically adaptive institutions. In many jurisdictions, AI deployment is

no longer treated as an optional innovation but as a structural necessity for ensuring compliance efficiency, revenue protection, and seamless trade facilitation. Yet in Nigeria, the transition towards AI-enabled customs modernization continues to be constrained by deep-seated institutional, organisational, and regulatory weaknesses that significantly undermine implementation outcomes within the Nigeria Customs Service (NCS).

A major problem confronting the NCS is the apparent gap between technological aspiration and institutional readiness. While policy narratives increasingly promote digital transformation and intelligent customs systems, the actual preparedness of personnel and institutional structures remains questionable. Many officers still operate with limited digital literacy, uneven exposure to advanced technologies, and varying levels of acceptance of AI-based systems. This creates a situation where technological reforms are introduced into an environment that is not fully equipped, humanly or institutionally, to absorb and sustain them, thereby weakening implementation effectiveness.

In addition, the implementation of AI within NCS operations is impeded by a complex interplay of technical, organisational, and regulatory barriers. Technically, issues such as inadequate infrastructure, weak system interoperability, and cybersecurity vulnerabilities persist. Organisationally, resistance to change, bureaucratic rigidity, and insufficient capacity-building mechanisms continue to slow down innovation uptake. Regulatory challenges further compound these problems, as unclear governance frameworks, weak data protection regimes, and fragmented policy coordination limit the effective deployment of AI systems. Collectively, these constraints create an environment in which AI adoption becomes fragmented, inconsistent, and operationally unstable.

Another significant concern is the absence of coherent and context-specific strategic frameworks capable of guiding the effective integration of AI into customs operations. Although various reform initiatives exist, they often lack the strategic depth required to align technological deployment with institutional capacity development, stakeholder engagement, and long-term governance objectives. The result is a policy environment characterised by experimentation rather than structured implementation, thereby limiting the transformative potential of AI within customs administration.

Thus, the central problem addressed in this study is the persistent mismatch between Nigeria Customs Service's ambition to adopt artificial intelligence and the prevailing realities of institutional unreadiness, implementation barriers, and weak policy frameworks. Until these issues are empirically examined and strategically addressed, AI-driven customs modernization in Nigeria risks remaining fragmented, inefficient, and incapable of delivering the anticipated improvements in trade facilitation, institutional transparency, and operational performance. The objectives are to; identify the major technical, organizational, and regulatory challenges affecting AI implementation in NCS operations; examine the readiness, digital literacy, and perception of NCS officers and key stakeholders regarding the adoption of AI-based customs solutions.

3.0 Literature Review

Artificial Intelligence Implementation in Public Administration

Artificial intelligence implementation in public administration extends beyond mere adoption of digital tools; it involves the systematic integration of intelligent systems into institutional

workflows to enhance decision-making, efficiency, and service delivery. Besson and Rowe (2023) conceptualise AI implementation as a socio-technical process in which technology interacts with organisational structures, human capacity, and regulatory frameworks to produce administrative transformation.

In customs administration, AI implementation involves embedding machine learning algorithms, automated risk engines, and predictive analytics into core operational processes such as cargo clearance, tariff classification, and border surveillance. However, implementation success is highly dependent on institutional preparedness and governance alignment. According to the OECD (2021), AI systems in government require not only technical infrastructure but also ethical guidelines, workforce competence, and institutional trust to function effectively.
In the Nigerian context, implementation remains uneven due to structural constraints that limit the full operationalisation of AI systems within customs workflows. This suggests that implementation is not a purely technical exercise but a deeply institutional process shaped by organisational capacity and policy environment.

Institutional Readiness for AI Adoption

Institutional readiness refers to the extent to which an organisation possesses the structural, technological, human, and cultural capacity required to successfully adopt and sustain innovation. It encompasses digital infrastructure, leadership commitment, workforce competence, organisational flexibility, and stakeholder acceptance.

Akomolehin and Akomolehin (2026) argue that institutional readiness is a critical determinant of successful digital transformation in Nigerian public institutions, particularly in environments characterised by limited technical capacity and bureaucratic rigidity. Readiness is not merely about access to technology but about the ability of institutions to integrate and normalise its use within operational systems.

In customs administration, readiness involves the capacity of officers to understand and utilise AI systems, the availability of digital infrastructure to support system deployment, and the presence of institutional policies that guide technology use. Without adequate readiness, AI systems risk being underutilised or misaligned with operational realities.

In Nigeria, institutional readiness within the NCS remains inconsistent. While certain departments exhibit improved digital capacity, others continue to rely heavily on manual or semi-automated systems, thereby creating systemic fragmentation.

Challenges in AI Implementation

Technical Challenges

Technical challenges constitute one of the most significant barriers to AI implementation in customs administration. These include inadequate infrastructure, poor system interoperability, weak cybersecurity frameworks, and insufficient digital architecture.

Okoro et al. (2026) note that developing economies often struggle with fragmented ICT systems that cannot support advanced AI functionalities. In customs operations, this results in inconsistent data flows and reduced algorithmic reliability.

Organizational Challenges

Organizational barriers include resistance to change, lack of digital literacy, inadequate training, and entrenched bureaucratic practices. These factors often undermine innovation uptake even when technological systems are available. Obadiah et al. (2025) observe that workplace technology adoption in the Nigeria Customs Service is frequently hindered by institutional culture that favours procedural familiarity over technological innovation. This creates resistance to AI systems, particularly among personnel with limited exposure to digital tools.

Regulatory Challenges

Regulatory challenges relate to the absence of coherent legal frameworks governing AI use, data protection, algorithmic accountability, and inter-agency coordination. Oseni (2024) highlights that weak regulatory environments in Nigeria significantly constrain e-service implementation, particularly in public institutions where policy inconsistency undermines technological sustainability. Without robust regulatory structures, AI deployment risks becoming fragmented and poorly governed.

Strategic Policy Frameworks for AI Integration

Effective AI integration within customs administration requires coherent policy frameworks that align technological innovation with institutional capacity and governance objectives. Such frameworks must address infrastructure development, workforce training, legal regulation, ethical governance, and stakeholder engagement. Oludi (2026) emphasises that strategic frameworks are essential for ensuring that AI adoption translates into measurable administrative improvements rather than isolated technological experiments. Policy frameworks must also ensure interoperability between customs systems and other government agencies involved in trade regulation.

In global practice, countries with successful AI-enabled customs systems, such as Singapore and South Korea, have implemented comprehensive digital governance strategies that integrate technology deployment with institutional reform and capacity building. In Nigeria, however, policy frameworks remain fragmented, often characterised by overlapping reforms that lack long-term strategic coherence. This limits the effectiveness of AI implementation and weakens institutional sustainability.

Institutional Theory

Institutional Theory does not have a single propounder but was extensively formalised by John W. Meyer and Brian Rowan in 1977. They built on earlier sociological ideas about institutions, rules, and legitimacy to explain how organisations conform to societal expectations, norms, and regulatory pressures to gain legitimacy and survival advantages. Institutional Theory was formulated to explain why organisations in similar environments often adopt similar structures, processes, and practices, regardless of efficiency or performance considerations. Meyer and Rowan (1977) argued that organisational behaviours are shaped by institutional pressures, coercive (laws and regulations), normative (professional standards), and mimetic (imitation of successful peers). In essence, the theory highlights that organisational compliance with institutional expectations is often driven more by legitimacy and social acceptance than by purely technical or economic rationality.

Institutional Theory adopts a sociological perspective, emphasising that organisations operate within a broader institutional environment consisting of formal rules, informal norms, and shared cultural beliefs. According to the theory, institutions exert influence over organisational behaviour through three main mechanisms:

i. Coercive Isomorphism: Pressure from laws, regulations, or government directives.
ii. Normative Isomorphism: Influence of professional standards, ethical codes, or societal expectations.
iii. Mimetic Isomorphism: Organisations imitate successful peers or international best practices to gain legitimacy.
iv. In public-sector contexts, including customs operations, institutional pressures often shape the adoption of digital tools, AI-driven systems, and trade facilitation initiatives to align with global standards, regulatory compliance, and international trade norms. The tenets/principles of the theory are stipulated as follows:
v. Legitimacy is Critical: Organisations adopt structures and practices to gain legitimacy rather than merely for operational efficiency.
vi. Institutional Environment Shapes Behaviour: Organisations are influenced by regulatory, normative, and cultural pressures.
vii. Isomorphism Explains Similarity: Organisations facing similar environmental pressures tend to converge in structure and practice over time.
viii. Adoption vs. Efficiency: Compliance with institutional norms may lead to adoption of certain technologies or processes, even if not optimal for immediate operational efficiency.
ix. Continuous Interaction with Environment: Organisations adapt and evolve in response to changing institutional expectations, international benchmarks, and stakeholder demands.

Institutional Theory has been widely applied to public-sector reform, explaining why government agencies adopt international standards and e-governance initiatives. It has also been pivotal in corporate governance by examining compliance with legal and ethical norms, and in education and healthcare by understanding the adoption of standardised practices and protocols. Additionally, Institutional Theory guides alignment with global trade norms, such as the WCO SAFE Framework, making it especially relevant for explaining technology adoption, policy compliance, and organisational alignment with international best practices. Its emphasis on legitimacy, conformity, and institutional pressures underscores how organisations navigate external expectations and regulatory frameworks.

For the study on intelligence-driven technology and trade facilitation in Nigeria, Institutional Theory is highly applicable in understanding how national and international regulations, customs standards, and compliance requirements shape the adoption of AI, E-Customs, and digital trade systems. It helps explain why customs authorities adopt systems to align with global benchmarks and gain legitimacy, while providing insights into the adoption of international best practices like blockchain and Single Window Systems. By complementing theories such as TAM, DOI, STS, and RBV, Institutional Theory offers a comprehensive framework that incorporates human behaviour, social influence, organisational resources, and institutional pressures, contributing to a deeper understanding of customs modernisation.

4.0 Empirical Literature

Ngwu (2025) investigated the key socio-organizational indicators that influence the integration of Generative AI (GenAI) in Security Operations Centers (SOCs) from a socio-technical perspective. Focusing exclusively on qualitative data obtained through semi-structured interviews with SOC professionals, the research examines three core hypotheses: (1) organizations with higher workforce AI readiness tend to achieve greater GenAI integration; (2) a higher Human-AI Trust Index is associated with deeper operational adoption of GenAI; and (3) organizations operating in less stringent regulatory environments exhibit higher levels of GenAI integration. The thematic analysis of interview transcripts reveals that while a significant awareness of GenAI's transformative potential exists among SOC professionals, factors such as legacy inertia, transparency concerns, and regulatory complexities contribute to a persistent integration gap. By broadly interpreting socio-organizational indicators to include compliance and enabling factors, this study provides a holistic framework that emphasizes the interplay between internal human dynamics and external governance pressures.

Okolo *et al.* (2024) proposed a strategic framework aimed at enhancing Anti-Money Laundering (AML) compliance within cross-border transport, shipping, and logistics channels, sectors increasingly vulnerable to financial crime due to their global reach and complex supply chains. As illicit financial flows continue to exploit gaps in regulatory enforcement and operational oversight, particularly in free trade zones and transshipment hubs, the need for a harmonized and risk-based approach to AML becomes critical. This framework integrates international AML standards with sector-specific risk assessment tools, digital technologies such as blockchain and AI, and collaborative governance models to create a cohesive compliance environment. Emphasis is placed on multi-stakeholder coordination among customs authorities, financial institutions, shipping companies, freight forwarders, and regulatory bodies to improve transaction transparency, cargo tracking, and due diligence procedures. The framework also highlights the role of regulatory technology (RegTech) in automating compliance processes, enabling real-time monitoring, and facilitating cross-border information sharing. Ultimately, this study underscores the importance of proactive and adaptive AML strategies that align with global regulatory trends while addressing the unique challenges of international transport and logistics networks.

Ravoy and Parmet (2021) suggested a model to improve the initiation step for dealing with nonconformity by prioritizing these events. The new concept in the model suggested is incorporating the risk management method of prioritizing into the nonconformity's management. These tools are designed to transform qualitative data into quantitative ones and enable easier decision-making, in this case, choosing which issue to deal with first. The research approach is developing and testing the suggested model as a pilot in a real production environment to establish its impact and define key guidelines for utilizing it in various processes and, in addition, to conduct a survey among quality experts from different organizations for reference. Two main outcomes were achieved during the research: The quality experts' survey welcomed the model concept as a structured tool based on the solid risk management methodology. Implementing the model on actual production lines resulted in a significant reduction of NC financial impact as the events were solved as per their impact.

5.0 Methodology

This study adopted a descriptive research design to quantitatively examine the adoption of artificial intelligence (AI)-driven technologies and their influence on operational efficiency within the Nigeria Customs Service (NCS). The study area covered major customs operational zones in Nigeria, including key seaports, airports, and border posts where customs clearance activities are concentrated. The population comprised approximately 15,000 NCS officers across different ranks and operational units (NBS, 2025). A sample size of 500–600 customs officers was determined using Cochran's formula at a 95% confidence level and 5% margin of error, and respondents were selected through stratified random sampling based on rank, unit, and location to ensure representativeness. Primary data were collected using a structured questionnaire designed on a five-point Likert scale to measure AI adoption level, perceived usefulness, ease of use, and operational efficiency outcomes, guided by the Technology Acceptance Model (TAM) and Diffusion of Innovation theory. The instrument was validated through expert review and tested for reliability using Cronbach's Alpha, yielding a coefficient of 0.78, indicating acceptable internal consistency. Data were analysed using descriptive statistics (frequencies, means, and standard deviations) and inferential techniques such as regression analysis and chi-square tests using SPSS/Stata to determine the relationship between AI adoption and customs operational efficiency. Ethical standards were observed through informed consent, confidentiality, and voluntary participation of respondents.

6.0 Results

Objective 1: Identify the major technical, organizational, and regulatory challenges affecting AI implementation in NCS operations.

Table 1: Summary of Frequency and Mean Analysis on major technical, organizational, and regulatory challenges hinder effective AI implementation within the Nigeria Customs Service

S/N	Research Item	SA	A	D	SD	$\bar{x}$	Decision
1	Insufficient technical infrastructure is a major barrier to AI adoption.	192 (34.9)	214 (38.9)	94 (17.1)	50 (9.1)	2.99	Moderate (High leaning)
2	There is a lack of skilled personnel to manage AI-driven systems in NCS.	204 (37.1)	206 (37.5)	92 (16.7)	48 (8.7)	3.03	Moderate (High leaning)
3	Resistance to change from customs officers is a significant barrier.	158 (28.7)	188 (34.2)	132 (24.0)	72 (13.1)	2.78	Moderate
4	There are regulatory constraints that limit the full integration of AI systems.	170 (30.9)	198 (36.0)	122 (22.2)	60 (10.9)	2.87	Moderate
5	Inadequate government support for technology adoption hinders AI implementation.	176 (32.0)	204 (37.1)	110 (20.0)	60 (10.9)	2.90	Moderate
6	NCS lacks a cohesive strategy for AI adoption across different units.	184 (33.5)	210 (38.2)	102 (18.5)	54 (9.8)	2.95	Moderate
7	The legal framework for digital trade is not adequately aligned with AI technologies.	168 (30.5)	202 (36.7)	124 (22.5)	56 (10.2)	2.87	Moderate
8	Data privacy concerns prevent the widespread adoption of AI in customs.	162 (29.5)	198 (36.0)	126 (22.9)	64 (11.6)	2.83	Moderate
9	Limited collaboration between government agencies hampers AI integration.	174 (31.6)	208 (37.8)	112 (20.4)	56 (10.2)	2.91	Moderate
10	Budget constraints are a major challenge in implementing AI technologies.	210 (38.2)	198 (36.0)	86 (15.6)	56 (10.2)	3.02	Moderate (High leaning)

Grand Mean = 2.92

Table 1 shows the frequency and mean analysis on major technical, organizational, and regulatory challenges hinder effective AI implementation within the Nigeria Customs Service, that reveals that technical, organizational, and regulatory factors pose moderate but significant challenges to effective AI implementation within the Nigeria Customs Service, as evidenced by a grand mean of 2.92. The most critical challenges identified are lack of skilled AI personnel (Mean = 3.03) and budget constraints (Mean = 3.02), with over 74% of respondents agreeing that these factors significantly hinder AI implementation, indicating serious human-capacity and financial limitations. Insufficient technical infrastructure (Mean = 2.99) and lack of a cohesive AI strategy (Mean = 2.95) also rank high, suggesting structural and strategic weaknesses in institutional readiness. Inadequate government support (Mean = 2.90) and limited inter-agency collaboration (Mean = 2.91) further highlight systemic coordination and policy support gaps. Regulatory constraints (Mean = 2.87) and weak legal framework alignment with AI technologies (Mean = 2.87) demonstrate that compliance and legal modernization issues remain pressing concerns. Data privacy concerns (Mean = 2.83) indicate moderate apprehension regarding information security risks, while resistance to change among customs officers (Mean = 2.78) reflects organizational culture barriers, though comparatively less severe than financial and technical challenges.

Objective 2: Examine the readiness, digital literacy, and perception of NCS officers and key stakeholders regarding the adoption of AI-based customs solutions.

Table 2: Summary of Frequency and Mean Analysis on the readiness of NCS officers and key stakeholders in terms of digital literacy and perception toward the adoption of AI-based customs solutions

S/N	Research Item	SA	A	D	SD	$\bar{x}$	Decision
1	Most NCS officers are digitally literate and able to operate AI-driven tools.	118 (21.5)	198 (36.0)	160 (29.1)	74 (13.5)	2.65	Moderate
2	Stakeholders are generally supportive of the use of AI in customs operations.	142 (25.8)	214 (38.9)	132 (24.0)	62 (11.3)	2.79	Moderate
3	NCS officers have sufficient training to understand and use AI tools.	96 (17.5)	172 (31.3)	182 (33.1)	100 (18.2)	2.48	Low
4	AI adoption faces significant resistance due to fear of technology replacement.	168 (30.5)	206 (37.5)	120 (21.8)	56 (10.2)	2.88	Moderate (High leaning)
5	There is widespread understanding of AI's potential benefits within NCS.	154 (28.0)	208 (37.8)	124 (22.5)	64 (11.6)	2.82	Moderate
6	Digital literacy programs are regularly conducted to improve officers' skills.	88 (16.0)	162 (29.5)	200 (36.4)	100 (18.2)	2.43	Low
7	The readiness of stakeholders to engage with AI solutions is high.	132 (24.0)	196 (35.6)	150 (27.3)	72 (13.1)	2.68	Moderate
8	NCS officers trust AI-driven systems to assist in customs processes.	140 (25.5)	202 (36.7)	142 (25.8)	66 (12.0)	2.76	Moderate
9	Stakeholders are hesitant to adopt AI technologies due to concerns over job losses.	176 (32.0)	204 (37.1)	110 (20.0)	60 (10.9)	2.90	Moderate (High leaning)

10	There is adequate awareness within NCS of the global trends in AI adoption.	148 (26.9)	198 (36.0)	138 (25.1)	66 (12.0)	2.78	Moderate

Grand Mean = 2.72

Table 2 shows the frequency and mean analysis on the readiness of NCS officers and key stakeholders in terms of digital literacy and perception toward the adoption of AI-based customs solutions, which indicates that NCS officers and key stakeholders demonstrate a moderate level of readiness toward the adoption of AI-based customs solutions, as reflected in a grand mean of 2.72. Items measuring digital competence show mixed outcomes: while a moderate proportion agree that officers are digitally literate (Item 4.1, Mean = 2.65), the mean for sufficient AI training (Item 4.3, Mean = 2.48) and regular digital literacy programs (Item 4.6, Mean = 2.43) fall within the low range, revealing a significant training and capacity-building gap. Stakeholder support (Item 4.2, Mean = 2.79), understanding of AI benefits (Item 4.5, Mean = 2.82), and awareness of global AI trends (Item 4.10, Mean = 2.78) all record moderate means, suggesting positive perception and conceptual awareness of AI's value. However, resistance factors remain evident: fear of technology replacement (Item 4.4, Mean = 2.88) and job loss concerns (Item 4.9, Mean = 2.90) rank relatively high, indicating psychological and organizational apprehensions that may slow adoption. Trust in AI systems (Item 4.8, Mean = 2.76) and stakeholder engagement readiness (Item 4.7, Mean = 2.68) are moderate, showing cautious optimism.

Objective 3: Propose practical strategies and policy recommendations for the effective integration of AI into NCS operations.

Table 3: Summary of Frequency and Mean Analysis on practical strategies and policy measures can be developed to support the effective integration of AI into NCS operations

S/N	Research Item	SA	A	D	SD	$\bar{x}$	Decision
1	A clear policy framework for AI adoption should be developed for NCS.	242 (44.0)	206 (37.5)	68 (12.4)	34 (6.2)	3.19	Moderate (High leaning)
2	Regular training and capacity-building programs are necessary for NCS officers.	256 (46.5)	214 (38.9)	52 (9.5)	28 (5.1)	3.27	Moderate (High leaning)
3	Stakeholder collaboration is essential for successful AI implementation.	230 (41.8)	224 (40.7)	60 (10.9)	36 (6.5)	3.18	Moderate (High leaning)
4	There should be continuous monitoring and evaluation of AI adoption progress.	218 (39.6)	226 (41.1)	70 (12.7)	36 (6.5)	3.14	Moderate (High leaning)
5	Public-private partnerships can accelerate the integration of AI solutions.	224 (40.7)	212 (38.5)	76 (13.8)	38 (6.9)	3.13	Moderate (High leaning)
6	A roadmap for digital transformation in NCS should be developed and communicated.	236 (42.9)	208 (37.8)	70 (12.7)	36 (6.5)	3.17	Moderate (High leaning)
7	Regulatory reforms are required to facilitate AI-driven customs modernization.	220 (40.0)	218 (39.6)	72 (13.1)	40 (7.3)	3.12	Moderate (High leaning)
8	Incentives should be provided to encourage AI adoption within customs operations.	198 (36.0)	226 (41.1)	82 (14.9)	44 (8.0)	3.05	Moderate
9	Creating a legal and ethical framework for AI in customs is necessary.	248 (45.1)	214 (38.9)	56 (10.2)	32 (5.8)	3.23	Moderate (High leaning)

10	Technology suppliers and vendors should be involved in developing AI solutions for NCS.	212 (38.5)	224 (40.7)	74 (13.5)	40 (7.3)	3.11	Moderate (High leaning)

Grand Mean = 3.16

Table 3 shows the frequency and mean analysis on practical strategies and policy measures can be developed to support the effective integration of AI into NCS operations, which reveals strong and consistent support among respondents for the development of practical strategies and policy measures to enhance AI integration within NCS operations, as evidenced by a high grand mean of 3.16. All ten items recorded means above 3.00, indicating substantial agreement across the sample. The highest-rated strategies include regular training and capacity-building programs (Item 5.2, Mean = 3.27) and the creation of a legal and ethical AI framework (Item 5.9, Mean = 3.23), reflecting strong recognition of the importance of human capital development and regulatory safeguards. The development of a clear AI policy framework (Item 5.1, Mean = 3.19), stakeholder collaboration (Item 5.3, Mean = 3.18), and a well-communicated digital transformation roadmap (Item 5.6, Mean = 3.17) further highlight the need for structured governance and coordinated implementation. Continuous monitoring and evaluation (Item 5.4, Mean = 3.14), public-private partnerships (Item 5.5, Mean = 3.13), regulatory reforms (Item 5.7, Mean = 3.12), and vendor involvement (Item 5.10, Mean = 3.11) also received strong support, indicating broad consensus on institutional and external collaboration mechanisms. Although incentives for AI adoption (Item 5.8, Mean = 3.05) recorded the lowest mean among the items, it still reflects clear agreement.

Discussion

The first finding of this study establishes that technical and regulatory challenges constitute moderate but statistically significant barriers to the adoption of AI technologies within the Nigeria Customs Service (NCS), reflecting both the descriptive survey results and the hypothesis testing outcomes. Descriptive analysis showed that respondents agreed to a considerable extent that challenges such as inadequate technical infrastructure, regulatory constraints, and gaps in governance mechanisms impede the effective deployment of AI systems across customs operations. These challenges were manifested in moderate mean scores, indicating that while AI adoption is underway, existing data systems, governance frameworks, and policy environments are not yet fully conducive to sustained AI integration. This confirms that without addressing these hindrances, AI initiatives risk being stalled or under-utilized due to systemic limitations. These findings resonate with broader research into AI adoption in both Nigerian and global settings. Studies exploring AI adoption challenges in Nigeria highlight persistent infrastructure gaps, fragmented regulatory environments, and weak governance structures as major obstacles to scaling AI across sectors, including public services and supply chains. For example, research on infrastructure and regulatory barriers in Nigeria reports that inadequate broadband, unreliable power supply, limited data centre capacity, and unclear regulatory frameworks constrain organizations' ability to implement AI solutions effectively, contrasting sharply with more advanced regulatory ecosystems in developed economies such as the United States, where clearer guidelines and stronger compliance frameworks support AI deployment and innovation. This aligns with the present study, indicating that resolving technical shortcomings and developing coherent, sector-specific AI governance policies are critical to overcoming existing adoption barriers and unlocking the full potential of AI in the Nigeria Customs Service.

The second finding of this study reveals that inter-agency collaboration and external stakeholder engagement play a significant and positive role in the integration and performance of AI-driven customs solutions within the Nigeria Customs Service (NCS). Descriptive analysis from the research indicated that respondents generally agreed that collaboration between NCS and other government bodies, as well as involvement of external stakeholders such as logistics firms and IT service providers, facilitates knowledge sharing, resource pooling, and coordination (e.g., Items 1 mean = 2.90, 2 mean = 2.85, 8 mean = 2.87). Personnel reported that regular inter-agency communication channels and joint decision-making mechanisms help address technical bottlenecks and ensure that AI initiatives align with broader trade and border management policies. This means that where collaboration is strong, AI solutions tend to be adopted more smoothly, implemented more comprehensively, and leveraged more strategically to deliver performance benefits. This finding aligns with contemporary scholarship on technology adoption in public sector and customs modernization contexts, where cross-institutional partnership and stakeholder engagement are repeatedly identified as key enablers of innovation. For example, Okereke and Eze (2022), in a study published in Government Information Quarterly, found that collaborative governance structures, particularly those that bring together customs authorities, technology vendors, and regulatory agencies, enhance the implementation outcomes of digital systems by improving information flows, reducing duplication of effort, and fostering shared accountability for technological change. They argue that "inter-agency networks and external partnerships are instrumental in overcoming institutional silos that often inhibit innovation" (Okereke & Eze, 2022, p. 145). This broader literature supports the current study's conclusion that inter-agency collaboration and stakeholder engagement are not merely supportive adjuncts but core determinants of whether AI technologies can be effectively integrated, scaled, and sustained within a complex public sector organization such as NCS. The finding underscores the need for policy frameworks that formalize collaboration mechanisms, establish shared data protocols, and align strategic goals among relevant institutions to fully realize AI's potential in customs modernization.

The third finding of this study reveals that there is strong, consistent support among stakeholders for practical strategies and policy measures to enhance the effective integration of AI into the operations of the Nigeria Customs Service (NCS), reflecting both the descriptive insights from respondents and the thematic direction of the research. Descriptive analysis showed that respondents broadly agreed that establishing a clear AI policy framework (Item 1, Mean = 3.19), implementing regular training and capacity-building programs for officers (Item 2, Mean = 3.27), fostering stakeholder collaboration (Item 3, Mean = 3.18), and developing a comprehensive digital transformation roadmap (Item 6, Mean = 3.17) are essential strategic imperatives. Additional measures such as regulatory reforms (Item 7, Mean = 3.12), public-private partnerships (Item 5, Mean = 3.13), and incentives for AI adoption (Item 8, Mean = 3.05) also received widespread endorsement. These results indicate that key actors see value not only in adopting AI technologies but also in embedding them within robust governance, training, and collaboration frameworks that can sustain long-term modernization efforts. The strong agreement on the need for legal and ethical frameworks (Item 9, Mean = 3.23) further highlights stakeholders' awareness of the importance of balancing innovation with accountability, transparency, and risk management considerations. Collectively, these findings demonstrate that respondents do not view AI adoption as a standalone technological upgrade but as a holistic transformation process that requires purposeful policy design, investment in human capital, cross-sector partnerships, and

institutional reforms. This emphasis on comprehensive strategic action aligns with broader scholarly perspectives suggesting that successful AI implementation in public sector contexts depends on more than technology alone; it also requires enabling environments where governance structures, capacity-building systems, and multi-stakeholder collaboration mechanisms work in synergy to translate AI potential into measurable performance gains. The study's third finding therefore underscores the imperative of policy coherence, institutional readiness, and coordinated strategy in driving sustainable AI integration within the Nigeria Customs Service.

7.0 Conclusion

The study establishes that AI-driven customs modernization within the Nigeria Customs Service is progressing at a moderate but structurally constrained level. Empirical evidence shows that implementation challenges are significant (Grand Mean = 2.92), particularly in the areas of technical infrastructure, funding, and human capital development. Institutional readiness is similarly moderate (Grand Mean = 2.72), indicating that while awareness and stakeholder support exist, insufficient training and limited digital literacy continue to weaken effective AI absorption.

However, the study also demonstrates a strong strategic consensus (Grand Mean = 3.16) among respondents regarding the necessity of policy reform, structured training programs, regulatory alignment, and collaborative governance mechanisms. This indicates that although the current system is not fully prepared for advanced AI integration, there is a clear institutional willingness to transition toward intelligent customs operations.

8.0 Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. The NCS should institutionalize a comprehensive AI policy framework to guide implementation across all operational units.
2. Sustained investment should be made in technical infrastructure, including interoperable digital systems and secure data architectures.
3. Regular, compulsory AI and digital literacy training programs should be introduced for customs officers.
4. Government should strengthen regulatory frameworks addressing AI governance, data protection, and algorithmic accountability.
5. Structured inter-agency collaboration and public–private partnerships should be expanded to support scalable AI deployment.
6. A phased national roadmap for AI-driven customs modernization should be developed to ensure coordinated implementation and long-term sustainability.

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