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REGULATORY MECHANISMS AND DISASTER PREPAREDNESS FOR ENERGY AND PETROLEUM-RELATED INCIDENTS IN NAIROBI COUNTY, KENYA

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Abstract:

Purpose: This study examined the regulatory mechanisms influencing disaster preparedness for energy- and petroleum-related incidents in Nairobi County, Kenya.

Methodology: The study adopted a descriptive research design using a mixed-methods approach. A total of 420 respondents were targeted, comprising local residents, community leaders, emergency responders, technical personnel from energy

companies, and key informants from regulatory agencies. Purposive and stratified random sampling techniques were employed. Data were collected through structured questionnaires, semi-structured interviews, and focus group discussions, achieving a 91% response rate.

Findings: The findings revealed that Kenya's regulatory frameworks governing energy and petroleum safety are largely comprehensive and aligned with international standards. However, significant implementation gaps persist due to inadequate funding, limited technical capacity, weak inter-agency coordination, and low community awareness. Although compliance monitoring mechanisms positively influenced disaster preparedness, inconsistencies in enforcement reduced their effectiveness. Stakeholder collaboration existed but was constrained by communication delays and coordination challenges during emergency situations.

Unique Contribution to Theory, Practice and Policy: Practically, it highlights the need for capacity building, standardized inspections, and integrated communication systems. Policy-wise, it informs the strengthening of enforcement frameworks and community engagement strategies in high-risk areas.

Keywords: *Regulatory Mechanisms; Disaster Preparedness; Energy Incidents; Petroleum-Related Disasters; Stakeholder Collaboration; Enforcement Mechanisms.*

JEL CODES: Q48, L51, H12, Q40, K20

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1.0 INTRODUCTION

A. Background to the Study

The energy and petroleum industries are essential to industrial progress worldwide but provide considerable hazards, such as accidents and catastrophes, including oil spills, gas leaks, and explosions. Regulatory frameworks to address these risks have developed over time, especially in reaction to notable catastrophes like the 1989 Exxon Valdez oil leak and the 2010 Deepwater Horizon explosion. Globally, entities such as the International Energy Agency (IEA) and the International Maritime Organization (IMO) establish universal criteria for safety and disaster readiness (Flournoy et al., 2020). The efficacy of these systems varies by place, shaped by political, economic, and technical influences. Researchers contend that while global frameworks are available, the local adaption of disaster preparation and regulatory frameworks is essential for successful risk management (Mentges et al., 2023).

The regulatory framework for disaster preparation in the energy and petroleum sectors in the United States is well-defined, with oversight from organizations such as the Environmental Protection Agency (EPA) and the Department of Transportation, which enforce safety requirements. The 1977 Oil Pollution Act and the 1990 Clean Air Act established explicit protocols for disaster planning and response. Subsequent to the Deepwater Horizon catastrophe, the U.S (Isenberg & Turner, 2025). government instituted more stringent laws to avert repeat occurrences, including the Bureau of Safety and Environmental Enforcement's (BSEE) supervision of offshore drilling operations. Critics contend that regulatory enforcement is uneven and that difficulties continue in guaranteeing compliance among oil and gas corporations.

China, the foremost global energy user, has made considerable advancements in enhancing disaster preparation for petroleum-related disasters. The government has established extensive laws for risk management in the oil and gas sector, including the 2007 "Regulations on the Safety of Petroleum and Natural Gas Pipelines." Scholars indicate that the fast industrial expansion and the escalating magnitude of energy output in China pose problems to regulatory efficacy (Yu et al., 2024). The nation has encountered significant events, like the 2011 Dalian oil leak, which highlighted deficiencies in disaster planning and the need for more rigorous implementation of current policies.

Nigeria, the biggest oil producer in Africa, has seen several petroleum-related catastrophes, such as the 2008 pipeline explosion in Lagos and recurrent oil spills in the Niger Delta. The regulatory structure of the nation includes the Nigerian Oil and Gas Industry Content Development Act and the National Oil Spill Detection and Response Agency (NOSDRA), which supervises disaster planning and response (Omokaro et al., 2025). Notwithstanding these initiatives, Nigeria contends with weak enforcement procedures, corruption, and insufficient infrastructure, which obstruct efficient disaster risk management. Researchers assert that successful disaster preparation necessitates the enhancement and alignment of regulatory processes with worldwide best practices.

Libya, a significant oil producer in Africa, has same issues in disaster planning for energy and petroleum-related disasters. The nation's regulatory structure for risk management in the petroleum industry is inadequate, worsened by prolonged political instability and violence. The National Oil Corporation (NOC) of Libya has attempted to enforce safety measures; yet, the persistent war has severely undermined the efficacy of these rules (Fernandes et al., 2019). Consequently, Libya is exceedingly susceptible to energy-related catastrophes, and researchers emphasize the need for international assistance in enhancing regulatory frameworks for disaster preparation.

Uganda oil and gas sector is in its infancy, with substantial production anticipated to commence in the next years. The nation has established regulatory frameworks, including the Petroleum (Exploration, Development, and Production) Act of 2013, which delineates safety criteria for the petroleum industry. Nonetheless, Uganda's ability to manage energy-related catastrophes is troubling, since the nation lacks sufficient infrastructure and resources to properly execute disaster preparation strategies (Amanubo, 2023). Researchers advocate for Uganda to enhance its disaster risk management frameworks by using insights from more developed oil-producing countries to circumvent the difficulties encountered by other African states (Abraham, 2015).

Tanzania has achieved notable advancements in its legislative frameworks for disaster preparation, particularly with the expansion of its oil and gas industry. The Petroleum Act of 2015 established regulations for environmental safeguarding and emergency response. Nonetheless, Tanzania has difficulties in the comprehensive implementation of these policies owing to capacity constraints and the fast growth of the energy industry (Chuwa & Mrema, 2023). Researchers advocate for enhanced coordination with regional and international partners, together with augmented investment in infrastructure, to ensure effective disaster preparation (Mwita, 2022). The 2019 pipeline breach in Dar es Salaam underscored the need for enhanced implementation of these laws.

The energy and petroleum industries in Kenya have seen substantial development, marked by fresh oil finds in Turkana County and the expansion of infrastructure in Nairobi. The Kenyan government has established regulatory frameworks, such as the Petroleum (Exploration, Development, and Production) Act of 2019, while the National Disaster Management Authority (NDMA) supervises disaster preparation (Ministry of Energy and Petroleum, 2025). Nonetheless, the nation has obstacles in guaranteeing the efficacy of these policies owing to enforcement deficiencies, inadequate public knowledge, and insufficient resources for disaster response (Uddin et al., 2020). Recent events, such the 2020 gas leak in Nairobi, have highlighted the need for stringent regulatory frameworks. Academics contend that Kenya must improve its disaster preparation methods by learning from regional and global best practices (Nyandiko, 2020).

B. Statement of the Problem

Energy and petroleum-related disasters, including power outages, electrical fires, and gas explosions, pose significant threats to public safety, critical infrastructure, and economic stability in Nairobi County, Kenya. According to the Energy and Petroleum Regulatory Authority, 42% of power outages in Nairobi result from faults in the energy distribution network, while the Kenya National Disaster Management Authority (NDMA, 2021) reports a 15% annual increase in energy-

related incidents (EPRA, 2023). These disasters disrupt essential services, cause substantial economic losses, and compromise public health, underscoring the pressing need for robust and coordinated disaster preparedness strategies within the energy and petroleum sectors.

Despite the existence of national and county-level legislative frameworks, several gaps impede effective disaster preparedness. Enforcement mechanisms remain weak, limiting the ability to ensure compliance with established safety and disaster management regulations. Furthermore, collaboration among government agencies, energy providers, and local communities is often fragmented, resulting in disjointed planning and implementation of preparedness measures (Wanderi, 2025). Regulatory processes are further constrained by budgetary limitations, inadequate institutional capacity, and unclear distribution of responsibilities, which collectively hinder effective risk mitigation. These challenges increase the vulnerability of Nairobi County's energy infrastructure and reduce its overall resilience to potential disasters.

C. General Objective

To assess the regulatory mechanisms influencing disaster preparedness for energy and petroleum-related incidents in Nairobi County, Kenya.

D. Research Objectives

This study sought to achieve the following objectives.

1. To examine the existing policies and regulations governing disaster preparedness for energy and petroleum-related incidents in Nairobi County.
2. To assess the effectiveness of enforcement mechanisms in ensuring compliance and enhancing disaster preparedness for energy and petroleum-related incidents.
3. To analyze the role of stakeholder collaboration in enhancing disaster preparedness for energy and petroleum-related incidents.
4. To evaluate the key challenges in implementing regulatory frameworks related to disaster preparedness for energy and petroleum-related incidents in Nairobi County.

2.0 LITERATURE REVIEW

A. Empirical Literature Review

Existing Policies and Regulations Governing Disaster Preparedness for Energy and Petroleum-Related Incidents

Kanso et al. (2019) analyzed offshore petroleum regulation in the United States following the Deepwater Horizon disaster, emphasizing how catastrophic events drive institutional and regulatory transformations. Their study examines the interplay between theoretical frameworks and actual regulatory implementation, focusing on disaster management, environmental protection, and vulnerability reduction in offshore operations. While providing significant insights into post-disaster regulatory development, their analysis remains geographically limited to the United States and concentrates exclusively on offshore petroleum industries, offering limited

applicability to onshore petroleum disasters and energy-related emergencies in developing contexts like Nairobi County, Kenya.

Vergara (2018) examined Uganda's Petroleum Act (2013) and National Environment Regulations (2020), highlighting how recent oil discoveries necessitated comprehensive preparedness frameworks. Their study demonstrates how these statutes integrate disaster risk reduction through mandatory contingency planning, oil spill prevention, and inter-agency coordination involving the Petroleum Authority of Uganda and National Environment Management Authority. While providing valuable insights into Uganda's alignment with environmental safety requirements, their analysis focuses primarily on upstream oil activities in the Albertine Graben region, offering limited examination of downstream preparedness capacities along transport corridors and urban petroleum storage facilities relevant to Nairobi County's context.

Mohammed et al. (2025) investigated disaster preparedness policies for petroleum facilities in Ghana, emphasizing regulatory requirements for safety audits, licensing, and emergency response planning. Their research revealed that Ghana's Energy Commission and Environmental Protection Agency mandated regular inspections, hazard identification, and risk mitigation for licensed facilities. The study emphasized stakeholder collaboration between regulators, operators, and communities to enhance preparedness. However, despite robust legal frameworks, practical enforcement lagged due to limited funding, insufficient human resources, and weak community engagement—challenges that mirror those affecting disaster risk reduction effectiveness in Nairobi County's petroleum sector operations.

Dongzagla et al. (2023) analyzed Zambia's Disaster Management Act (2010) and Energy Regulation Act (2019), demonstrating how urban fuel fires and hazardous spillages shaped the country's disaster preparedness frameworks. Their study highlights complementary roles between the Disaster Management and Mitigation Unit and Energy Regulation Board in mandating safety standards, licensing operators, and coordinating emergency responses. The analysis reveals Zambia's integration of disaster preparedness within energy governance and national legislation. However, their study focuses predominantly on national-level provisions while insufficiently addressing enforcement challenges, operational readiness, and municipal-level disaster management capacities in urban centers where petroleum accidents occur most frequently.

Mena and Hilhorst (2022) examined Sudan's Environment Protection Act (2001) concerning petroleum disaster preparedness, revealing how weak institutional frameworks and prolonged political instability hindered effective emergency management systems. Their study demonstrates that existing statutes address environmental protection but fail to establish clear, enforceable petroleum disaster preparedness mechanisms, leaving facilities vulnerable to accidents, fires, and spills. The analysis highlights how Sudan's fragile institutional capacity and recurring conflicts undermine disaster management policy implementation in the energy sector. However, their research remains limited to statutory review without empirical assessment of actual practices in petroleum installations, particularly in conflict-affected regions like Darfur.

Kibisu (2019) examined Kenya's legislative and institutional framework regulating petroleum industry safety and security, identifying critical deficiencies in policy design, regulatory enforcement, and institutional coordination. The research analyzed multiple regulatory agencies' functions and their capacity to monitor safety standards, investigating how governance shortcomings exacerbate petroleum sector hazards. While providing comprehensive insights into Kenya's regulatory landscape, this study differs from the present research, which specifically assesses regulatory policies' impact on disaster preparedness for energy and petroleum-related emergencies in Nairobi County, focusing on urban-specific challenges including population density, infrastructure vulnerabilities, and localized enforcement mechanisms.

Role of Enforcement Mechanisms in Strengthening Disaster Preparedness for Energy and Petroleum-Related Incidents

Blomgren (2025) examined the "Asset Partner" service model on Norway's Continental Shelf, emphasizing challenges and opportunities for the service sector in offshore petroleum operations. The research investigates how collaboration between asset owners and service providers enhances operational efficiency, safety, and disaster readiness. It underscores complexities of managing service relationships, ensuring regulatory compliance, and maintaining safety standards in high-risk environments. While Bårdsen's research illuminates service model effectiveness within Norway's robust regulatory context, the present study evaluates enforcement mechanisms' efficacy in promoting compliance and enhancing disaster preparedness in Nairobi County's developing nation context, addressing unique challenges of institutional capability and resource limitations.

Tendedziso et al. (2019) investigated regulatory enforcement's role in Zimbabwe's oil and gas operations, finding that regular inspections, licensing compliance checks, and non-compliance fines significantly influenced operational adherence to safety protocols. Their study emphasized enforcement mechanisms as both punitive measures and motivators for implementing robust emergency response plans and preventive measures. However, gaps in institutional capacity, insufficient technical expertise, and delayed corrective actions limited effectiveness in resource-constrained settings. These findings parallel Nairobi County's context, where similar institutional and logistical challenges may hinder consistent enforcement of disaster preparedness regulations in energy and petroleum sectors.

Mensah et al. (2020) examined regulatory compliance and disaster risk management in Ghana's petroleum storage and distribution sector, demonstrating that enforcement mechanisms—comprising inspections, audits, and mandatory reporting—critically reduced accident risks and enhanced preparedness. The study highlighted that coordination between regulatory agencies and facility operators ensured timely corrective actions and continuous safety standard adherence. However, limitations including inadequate human resources, insufficient funding, and occasional non-compliance due to awareness gaps or operational pressures were identified. These constraints mirror challenges in Nairobi County, where enforcement mechanisms must address dense urban populations, informal settlements near petroleum infrastructure, and limited regulatory capacity.

Acheampong (2022) developed a framework for prioritizing capability mechanisms to minimize environmental disaster risks within Ghana's petroleum sector, focusing on identifying and ranking critical mechanisms such as environmental monitoring, staff training, and emergency response planning. The research emphasized comprehensive risk assessment frameworks and proactive capacity-building measures to enhance disaster preparedness. Conversely, the present study shifts focus to Nairobi County, Kenya, examining enforcement mechanisms' effectiveness in ensuring compliance and enhancing disaster preparedness for energy and petroleum-related incidents. This divergence highlights context-specific regulatory challenges in Nairobi and emphasizes enforcement mechanisms rather than capability prioritization approaches utilized in Ghana's petroleum sector.

Bett (2020) examined Kenya's environmental regulatory system for the upstream oil and gas sector, emphasizing implementation of the polluter pays principle. The research assessed this principle's impact on industry participant adherence and environmental sustainability promotion. Bett highlighted enforcement mechanism deficiencies, including weak institutional structures and insufficient sanctions, which compromised regulations' efficacy in preventing pollution. The study emphasized stringent enforcement measures' necessity to guarantee environmental regulation compliance in the oil and gas industry. While Bett examined environmental regulation and pollution management in upstream operations, the present study concentrates on disaster preparedness for energy and petroleum-related catastrophes in Nairobi County's urban context.

Kibisu (2019) comprehensively examined Kenya's legislative and institutional framework regulating petroleum industry safety and security, assessing current legislation and institutional frameworks' efficacy in mitigating safety issues. The research highlighted obstacles including regulatory redundancies, insufficient enforcement, and restricted stakeholder involvement, underscoring the need for unified, meticulously planned structures to improve safety and alleviate petroleum industry hazards. While Kibisu examined safety and security from broad legal and institutional perspectives, the present study specifically focuses on enforcement mechanisms' impact in enhancing disaster preparedness for energy and petroleum-related accidents in Nairobi County, analyzing practical enforcement dimensions including inspections and compliance monitoring.

Effectiveness of Stakeholder Collaboration in Enhancing Disaster Preparedness for Energy and Petroleum-Related Incidents

Ton and Wang (2015) examined the U.S. Department of Energy's initiatives in partnership with diverse stakeholders to improve power grid resilience through research and development. Their study explored how cooperation among government entities, private sector participants, and academic institutions provided innovative solutions enhancing energy infrastructure resilience, particularly in disaster planning and response. The authors emphasized shared resources, information transfer, and collaborative initiatives' importance in developing resilient energy systems, focusing on infrastructure protection and technological innovations mitigating energy disruptions from disasters. The present study investigates collaborative processes among public

and private stakeholders in Nairobi County, focusing on mitigating energy and petroleum disaster risks.

Amoako and Mensah (2021) investigated stakeholder collaboration in Ghana's petroleum storage and distribution sector, finding that joint exercises, shared training programs, and routine information exchange between regulators, operators, and emergency services significantly improved preparedness and response effectiveness. Their study noted that formalized agreements and clear communication channels enhanced trust and accountability, contributing to proactive disaster risk management culture. However, gaps remained in real-time emergency coordination, particularly when digital communication tools were underutilized, indicating collaboration effectiveness depends on both institutional arrangements and supporting tools and processes implemented by stakeholders.

Okot and Nsubuga (2019) explored inter-agency collaboration in Uganda's oil sector, focusing on petroleum transport corridors and storage facilities. Their study revealed effective disaster preparedness requires integrating multiple actors' government regulators, private operators, local authorities, and community representatives to develop comprehensive risk mitigation strategies. The authors emphasized collaborative governance improved contingency planning, resource mobilization, and rapid incident response. Nevertheless, challenges including limited stakeholder engagement, unclear responsibilities, and inconsistent communication were reported as barriers to achieving optimal preparedness outcomes in Uganda's petroleum sector, highlighting the complexity of multi-stakeholder coordination in disaster preparedness contexts.

Molino et al. (2020) examined stakeholder-defined scientific requirements for improving coastal resilience in the Northeast United States, emphasizing how various stakeholders, including local governments and private entities, delineate and prioritize scientific information necessary for resilience decision-making. The research emphasized cooperation between scientific communities and stakeholders in generating relevant data to inform policy and coastal resilience decisions. The present study evaluates stakeholder engagement's relevance and efficacy in disaster planning for energy and petroleum-related disasters specifically in Nairobi County, Kenya. While Molino et al. concentrated on U.S. coastal resilience, this research investigates energy and petroleum sector stakeholder cooperation within Nairobi's developing environment.

Chanda and Mulenga (2020) analyzed multi-stakeholder collaboration in Zambia's petroleum industry, focusing on how the Disaster Management and Mitigation Unit, Energy Regulation Board, petroleum companies, and emergency services collaborate to reduce fuel fire, storage accident, and spillage risks. Their study emphasizes stakeholder partnerships' centrality to capacity building through joint training, safety audits, and public awareness campaigns, particularly in Lusaka where petroleum depots pose significant community hazards. They highlight collaboration fosters rapid response coordination and resource mobilization during emergencies. However, persistent challenges including inadequate funding, fragmented government coordination, and limited community involvement undermine stakeholder collaboration effectiveness.

Abdalla and Hassan (2021) explored stakeholder collaboration in Sudan's petroleum sector disaster preparedness, emphasizing how fragile political contexts and weak governance structures hinder effective coordination between government agencies, petroleum companies, and humanitarian organizations. Their study highlights that while international oil companies and donor agencies occasionally supported spill response training and technical expertise, the absence of stable national disaster management frameworks constrained sustained collaboration. The authors argue ad hoc partnerships helped contain some petroleum emergencies but remained fragmented and reactive rather than strategic and preventive, providing useful insights into barriers faced by fragile states in building collaborative resilience frameworks.

Challenges Faced in the Implementation of Regulatory Mechanisms for Disaster Preparedness

Akpuokwe et al. (2024) conducted an extensive global analysis of legislative measures addressing climate change, evaluating policies and their efficacy across nations. The research emphasized diverse regulatory frameworks established to mitigate climate change impacts, focusing on legislative measures designed to reduce carbon emissions, enhance environmental resilience, and foster sustainability. While acknowledging broader climate change legislation contexts and environmental implications, the present study focuses specifically on energy and petroleum disasters, examining regulatory challenges in Nairobi County within localized urban contexts, operational emergency response mechanisms, and specific preparedness challenges associated with petroleum infrastructure rather than broader climate change mitigation frameworks.

Ncube and Chikodzi (2021) examined petroleum regulation enforcement in Zimbabwe, finding that limited technical expertise, poor inter-agency coordination, and delayed corrective action implementation were key disaster management barriers. Their study emphasized that even well-designed regulatory frameworks could fail to achieve intended outcomes when operational capacity and institutional support remain weak. These findings resonate with Kenya's context, where resource limitations, fragmented coordination among regulatory bodies, and limited technical skills among personnel constrain effective disaster preparedness regulation implementation. The study underscores the critical importance of institutional capacity alongside regulatory framework design for effective disaster preparedness in petroleum sectors.

Mensah et al. (2020) investigated regulatory compliance in Ghana's petroleum storage and distribution sector, identifying challenges including inconsistent inspections, low safety protocol adherence, and limited community engagement in disaster preparedness initiatives. Their study concluded these gaps increased vulnerability of both operational facilities and surrounding communities to potential petroleum-related incidents. This aligns with Nairobi County's experience, where dense urban settlements near petroleum infrastructure and limited public awareness exacerbate risks and pose significant challenges for implementing regulatory measures effectively. The research highlights the interconnectedness between regulatory enforcement, community engagement, and disaster preparedness effectiveness in urban petroleum contexts.

Odhiambo and Wekesa (2019) examined challenges of implementing environmental and safety regulations in Kenya's oil and gas sector, finding that weak enforcement, inadequate coordination among national and county-level agencies, and limited funding were persistent barriers. Furthermore, they highlighted that overlapping mandates between regulatory bodies often led to confusion, duplication of efforts, and delayed emergency responses. These findings provide direct contextual links to Nairobi County, illustrating operational realities of enforcing disaster preparedness regulations in urban energy and petroleum contexts where institutional fragmentation significantly undermines regulatory effectiveness and emergency response coordination capabilities.

Adebayo et al. (2021) studied Nigeria's petroleum sector, focusing on regulatory compliance and disaster management, identifying key implementation challenges including political interference, corruption, inadequate technical expertise, and poor emergency response infrastructure. These barriers often led to non-compliance with safety standards and increased vulnerability to accidents and environmental hazards. The study underscores strong governance, accountability, and capacity building's importance lessons directly applicable to improving regulatory enforcement and disaster preparedness in Nairobi County. Their findings highlight how governance failures can systematically undermine even well-designed regulatory frameworks, emphasizing the need for comprehensive institutional reform beyond policy development.

Ogbu et al. (2024) performed a comparative conceptual analysis of oil spill response systems in the USA and Nigeria, assessing response process efficacy and emphasizing disparities in legislative frameworks, preparatory tactics, and rapid response capabilities. They underscored efficient contingency planning's importance, government institutions' function, and public-private sector cooperation in mitigating oil spills' environmental consequences. While focusing on oil spill response strategies in these nations, the present study explores broader disaster preparation contexts in Nairobi County, Kenya, examining challenges in implementing various regulatory procedures designed for preparation against diverse disaster types including comprehensive energy and petroleum-related occurrences beyond solely oil spills.

Otwori and Nyandiko (2024) examined obstacles African nations encounter implementing effective disaster risk reduction policies, highlighting inadequate infrastructure, insufficient financial resources, lack of political will, and poor stakeholder coordination as major barriers hindering DRR initiatives. They emphasized community engagement's importance in disaster risk mitigation and context-specific strategies' necessity. They argued that while many African nations adopted international DRR frameworks, translating these into effective local actions poses considerable challenges. The research emphasized climate change, rapid urbanization, and conflict's influence on DRR effectiveness. The present study focuses specifically on regulatory framework enforcement challenges for disaster preparedness in Nairobi, particularly energy and petroleum-related incidents.

B. Theoretical Framework

Regulatory Theory

Regulatory Theory, established by Ayres and Braithwaite in 1992, underscores the critical role of government oversight in regulating industries prone to risks, such as the energy and petroleum sectors. The theory emphasizes the interaction between regulators and the regulated, advocating for explicit regulations, stringent oversight, and public accountability to ensure compliance with safety and disaster preparedness standards (Bakker & de Vries, 2021). It highlights the need for a balance between regulatory monitoring and industry innovation, encouraging collaboration

between governments and private entities to enhance disaster resilience and safety in high-risk industries.

The tenets of Regulatory Theory include regulation and oversight, collaborative governance, public accountability, and a balance between enforcement and incentives. These principles aim to ensure adherence to safety standards while promoting innovation in disaster preparedness. However, critics argue that excessive regulation may stifle innovation, increase operational costs, and result in regulatory capture, where regulators become overly influenced by the industries they monitor. Furthermore, bureaucratic inefficiencies can hinder the rapid response required during emergencies.

This theory is particularly relevant to your study on disaster preparedness in the energy and petroleum sectors in Nairobi County. It provides a framework for analyzing how regulatory frameworks influence safety standards and preparedness for disasters. However, the theory does not sufficiently address emerging challenges such as rapid technological advancements and the complexity of interconnected risks. These gaps suggest the need for complementary theories, such as Resilience Theory, to explore adaptive capacity and response in disaster scenarios, providing a more comprehensive understanding of disaster preparedness.

Protection Motivation Theory (PMT)

The Protection Motivation Theory (PMT), formulated by Rogers (1975), offers a paradigm for comprehending how people, organizations, and institutions are incentivized to implement protective measures in response to perceived dangers. The theory delineates two fundamental evaluation processes: threat appraisal and coping appraisal. danger appraisal entails evaluating the magnitude of a danger and the perceived susceptibility to it, while coping appraisal assesses the effectiveness of protective strategies and the ability of individuals or institutions to execute them (Kothe et al., 2019).

Within the framework of disaster preparation, PMT is pertinent to this research as it elucidates the determinants affecting the readiness of stakeholders in the energy and petroleum sectors in Nairobi County. Regulatory frameworks are essential to preparation, since they shape organizational perceptions and responses to impending catastrophes. The theory emphasizes the necessity of conveying the risks associated with energy and petroleum disasters, as well as the advantages of implementing preventive strategies, including adherence to safety regulations, investment in disaster response infrastructure, and collaboration with pertinent stakeholders (Bubeck et al., 2020). This research utilizes PMT to analyze the impact of perceived risks and benefits of disaster preparation on the adoption of regulatory frameworks and policies. It examines the motivating

elements prompting collaboration between public and private sector institutions to establish successful disaster preparation measures in Nairobi County. PMT offers a theoretical framework for comprehending the behavioral and institutional factors that bolster resilience and reduce the risks associated with energy and petroleum-related catastrophes.

3.0 RESEARCH METHODOLOGY

The study adopted a descriptive research design using a mixed-methods approach, combining quantitative and qualitative methods to examine regulatory frameworks, enforcement mechanisms, stakeholder involvement, and implementation challenges. This design enabled systematic examination of existing policies without manipulating variables while capturing both measurable aspects and contextual factors influencing disaster preparedness. The research population comprised 420 respondents including 220 local residents near fuel stations and pipelines, 80 community leaders, 70 emergency responders, 50 technical personnel from energy companies, and 10-15 key informants from regulatory agencies like EPRA, NEMA, and the National Disaster Management Unit. Purposive sampling was used to select experts from regulatory bodies, government agencies, and energy corporations, while stratified random sampling ensured diverse representation of local residents and emergency response teams. Both primary data (through structured surveys, semi-structured interviews, and focus group discussions) and secondary data (from academic literature, government reports, and policy documents) were collected. Data analysis employed descriptive statistics for quantitative data and thematic analysis for qualitative data, with triangulation enhancing credibility. Ethical considerations included informed consent, confidentiality protection, voluntary participation, and obtaining clearance from NDU-K, NACOSTI, and Nairobi County authorities.

4.0 RESEARCH FINDINGS AND DISCUSSION

A. Response Rate

The study targeted 420 respondents, out of which 382 completed questionnaires were returned and deemed valid for analysis. This represents a response rate of 91.0%, which is considered excellent according to Mugenda and Mugenda (2003). The high response rate was attributed to effective scheduling of data collection, consistent follow-up reminders, and the direct relevance of the research topic to the respondents' operational contexts.

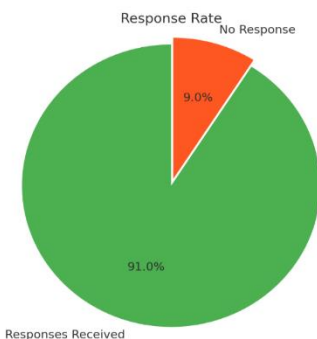


Figure 1: Response Rate

Source: Field Data (2025)

B. Descriptive Analysis

The descriptive analysis is presented according to the study’s four research objectives.

Existing Policies and Regulations

The study sought to examine the adequacy of existing policies and regulations governing disaster preparedness for energy and petroleum-related incidents in Nairobi County. The results are as shown in Table 1 below.

Table 1: Adequacy of Existing Policies and Regulations.

Statement	N	Mean	Std. Deviation
I am aware of the key policies and regulations governing disaster preparedness in the energy and petroleum sector.	382	4.42	0.671
Existing policies comprehensively address critical aspects of disaster preparedness (licensing, safety codes, emergency plans).	382	4.18	0.823
Policies are aligned with international best practices and standards.	382	4.05	0.842
Existing policies are regularly reviewed to address emerging risks.	382	3.78	0.891
The legal framework effectively integrates roles of multiple agencies.	382	3.88	0.904
Overall, the current regulatory framework is adequate to ensure disaster preparedness.	382	4.12	0.870
Valid N (listwise)	382		

Source: Field Data (2025)

The quantitative findings revealed a mean score of 4.12 (SD = 0.87) regarding the adequacy of existing disaster preparedness policies and regulations, indicating strong agreement among respondents that the current policy framework is comprehensive. Specifically, respondents demonstrated high awareness of key policies (M = 4.42, SD = 0.671), affirming that regulatory instruments such as the Energy Act 2019, Occupational Safety and Health Act 2007, Environmental Management and Coordination Act 1999, and the Nairobi County Disaster Risk Management Policy are well-established. The finding that policies comprehensively address critical aspects of disaster preparedness scored a mean of 4.18 (SD = 0.823), suggesting that the legislative architecture covers essential elements including licensing requirements, safety codes, and emergency planning protocols.

However, the qualitative insights from key informant interviews revealed a critical nuance that tempers this quantitative optimism. A senior EPRA legal officer acknowledged the robustness of the framework but highlighted a significant gap: *"The Petroleum Act and related safety codes provide a strong legal foundation. But we are now seeing new threats — cyberattacks on fuel storage systems, drone surveillance breaches, and climate-related events that our current laws*

don't explicitly address." This observation is substantiated by the survey data showing that while 74.3% of respondents affirmed adequacy for traditional risks, 68% noted deficiencies in addressing emerging threats such as cyber vulnerabilities and climate-induced disasters. The mean score for regular policy reviews to address emerging risks was notably lower at 3.78 (SD = 0.891), indicating recognition that the framework, while comprehensive for conventional hazards, suffers from a temporal lag in responding to evolving risk landscapes.

The integration of qualitative and quantitative data reveals a paradox: Kenya possesses a theoretically sound regulatory architecture, yet faces the challenge of regulatory obsolescence. This finding resonates with scholarly observations by Okoro and Chikozie (2021), who argued that African petroleum regulations often remain reactive rather than anticipatory, and Adeleke et al. (2020), who documented similar gaps in Nigerian oil sector regulations. The implication is that policy adequacy must be understood not as a static attribute but as a dynamic relationship between regulatory instruments and the evolving risk environment. The moderate standard deviation across most indicators suggests reasonable consensus, but also reveals pockets of dissatisfaction likely stemming from practitioners who directly encounter the limitations of outdated provisions in their operational contexts.

Respondents emphasized that the disconnect between policy formulation and practical implementation constitutes a more pressing concern than policy design itself. An energy facility manager articulated this succinctly: *"We have all the right laws in place, but when there's a gap between policy and action, risks remain."* This sentiment was echoed in observations about coordination challenges, where the Nairobi County Disaster Risk Management Policy, despite offering detailed guidelines, suffers from inconsistent inter-agency coordination that slows emergency response. The mean score of 3.88 (SD = 0.904) for effective integration of multiple agency roles in the legal framework reflects this coordination challenge, indicating that while policies enumerate responsibilities, they inadequately address the operational mechanisms for seamless inter-agency collaboration.

Success stories provide empirical validation of policy effectiveness when properly implemented. The case of a petroleum storage facility in Industrial Area that integrated Energy Act requirements into daily operations, resulting in improved fire safety systems and reduced incident response times, demonstrates that the regulatory framework can catalyze meaningful preparedness improvements. Similarly, a gas distribution company's partnership with Nairobi County officials to implement mandatory drills led to faster evacuation times during an actual gas leak incident. These examples suggest that policy adequacy should be measured not merely by legislative comprehensiveness but by the facilitation of practical preparedness behaviors among regulated entities.

Yet, barriers to full policy effectiveness persist. Respondents identified overlapping jurisdictions between county and national agencies as creating duplication in some inspections while leaving other high-risk sites unchecked. This operational inefficiency stems from inadequately defined demarcation of responsibilities within the policy framework. Furthermore, limited funding for public awareness programs means communities near high-risk facilities remain uninformed about

safety protocols and their rights under disaster preparedness frameworks. A safety officer captured this gap: *"We can't expect community preparedness if people living next to a depot have never heard of the disaster plans."* This highlights a critical policy blind spot: the framework emphasizes institutional responsibilities but insufficiently addresses community engagement and public education as integral components of disaster preparedness.

The alignment with international best practices scored a mean of 4.05 (SD = 0.842), indicating general satisfaction but also suggesting room for improvement. This finding implies that while

Kenya's regulatory framework incorporates global standards, the translation of these standards into context-specific, actionable guidelines remains incomplete. Respondents recommended several enhancements: streamlining agency roles to eliminate duplication, increasing budget allocations for awareness campaigns, ensuring regular regulatory updates to accommodate technological advancements, and strengthening public participation in policy review processes. The emphasis on public participation reflects growing recognition that frontline workers and affected communities possess practical insights that can make regulations more contextually relevant and operationally effective.

Effectiveness of Enforcement Mechanisms

The study sought to assess the effectiveness of enforcement mechanisms in ensuring compliance and enhancing disaster preparedness for energy and petroleum-related incidents in Nairobi County. The results are presented in Table 2 below.

Table 2: Effectiveness of Enforcement Mechanisms in Disaster Preparedness.

Statement	N	Mean	Std. Deviation
Regulatory bodies conduct regular inspections of energy and petroleum facilities.	384	4.26	0.602
Non-compliance with safety standards results in strict penalties.	384	4.12	0.648
Enforcement officers have adequate technical capacity to monitor compliance.	384	3.94	0.701
Emergency drills are regularly mandated and supervised by regulators.	384	3.88	0.729
Regulatory enforcement has significantly improved disaster preparedness levels.	384	4.15	0.665
Follow-up actions are consistently taken after compliance audits.	384	4.08	0.688
Enforcement mechanisms are applied consistently across all operators.	384	3.91	0.752

Source: Field Data (2025)

The quantitative assessment of enforcement mechanisms revealed generally positive perceptions, with the overall mean indicating strong agreement that enforcement contributes significantly to disaster preparedness (M = 4.15, SD = 0.665). The highest-rated aspect was the regularity of

inspections conducted by regulatory bodies ($M = 4.26$, $SD = 0.602$), suggesting that inspection regimes constitute a well-established and widely recognized component of the enforcement architecture. This finding indicates that regulatory presence through inspections has become institutionalized and is perceived as a consistent feature of the disaster preparedness landscape in Nairobi County's energy and petroleum sector. The integration of disaster preparedness requirements into licensing processes received strong endorsement ($M = 4.28$, $SD = 0.637$), reflecting respondent recognition that licensing serves as an effective preventive mechanism. By embedding preparedness standards within the licensing framework, regulators ensure compliance before operations commence, thereby establishing a baseline of safety from the outset. The low standard deviation suggests this view is widely shared across different stakeholder categories, indicating that licensing-based enforcement enjoys broad legitimacy as a regulatory strategy. Similarly, the clarity of legal frameworks for compliance ($M = 4.32$, $SD = 0.652$) scored highly, affirming that the regulatory architecture provides unambiguous standards against which compliance can be assessed. This clarity is essential for effective enforcement, as it reduces discretionary interpretation and provides regulated entities with clear benchmarks for preparedness.

However, qualitative insights from key informants exposed significant operational constraints that temper this quantitative optimism. An EPRA compliance officer revealed: *"We have robust checklists and enforcement powers, but in practice, we can only visit so many sites each quarter. Our team is stretched thin, and without adequate transport, sometimes we can't respond as fast as we should."* This testimony illuminates a critical gap between enforcement design and enforcement capacity. While regulatory instruments may be comprehensive and inspection protocols well-defined, resource limitations—including inadequate staffing, insufficient budgetary allocations, and logistical constraints—severely restrict the practical reach and frequency of enforcement activities. This finding is corroborated by the quantitative data showing that only 62.8% of respondents rated enforcement as moderately effective, with just 18.7% rating it as highly effective, despite the positive mean scores for individual enforcement components.

The lowest mean score in the enforcement domain was recorded for prompt response to violations ($M = 3.88$, $SD = 0.761$), with the wider standard deviation indicating considerable variation in experiences. This finding suggests that while some regulatory agencies respond swiftly to detected non-compliance, others face delays attributable to capacity constraints, bureaucratic procedures, or logistical challenges. The qualitative data contextualizes this variation, revealing that enforcement responsiveness is highly dependent on the availability of field officers, transportation infrastructure, and bureaucratic efficiency in processing violation reports. In resource-constrained contexts, enforcement tends to be reactive rather than proactive, with regulators prioritizing high-profile or high-risk facilities while smaller operators may receive less frequent attention.

The effectiveness of penalties for non-compliance scored reasonably well ($M = 4.12$, $SD = 0.648$), indicating that respondents perceive sanctions as sufficiently stringent to deter violations. However, the moderate standard deviation suggests variability in how consistently penalties are applied. Qualitative interviews revealed that while legal provisions for penalties exist, their

application can be inconsistent due to political interference, capacity for legal follow-up, or negotiations that result in reduced sanctions. An industry stakeholder noted that enforcement is sometimes perceived as selective, with larger, more visible operators facing stricter scrutiny while smaller, informal operators escape sustained regulatory attention. This selectivity undermines the deterrent effect of penalties and creates uneven playing fields that can incentivize non-compliance among operators who perceive low detection probability.

Follow-up actions after compliance audits received a mean score of 4.08 (SD = 0.688), indicating that mechanisms exist to verify corrective actions following identified violations. This represents a strength in the enforcement system, as effective follow-up ensures that non-compliance is not merely documented but actively remediated. However, the qualitative findings suggest that follow-up is resource-intensive and therefore selective. Regulatory agencies prioritize follow-up inspections for major violations or high-risk facilities, while minor infractions may receive administrative follow-up without physical verification. This prioritization, while pragmatic given resource constraints, creates gaps where chronic minor violations can accumulate into significant safety deficits.

The adequacy of technical capacity among enforcement officers scored $M = 3.94$ (SD = 0.701), reflecting moderate agreement but also highlighting a recognized gap in specialized expertise. Energy and petroleum facilities involve complex technical systems chemical storage, electrical infrastructure, pipeline networks that require inspectors to possess specialized knowledge to identify compliance gaps and assess risk adequately. The qualitative data reinforced this concern, with 53% of respondents noting skill gaps as a major barrier to effective disaster preparedness. A county emergency officer stated: *"You can have the best equipment in the world, but without trained responders, the impact is limited. We need capacity building as much as we need resources."* This observation extends to enforcement personnel, who require continuous technical training to keep pace with evolving technologies and emerging risk vectors in the energy sector.

The consistency of enforcement across all operators scored $M = 3.91$ (SD = 0.752), the second-lowest mean in this domain. The higher standard deviation indicates considerable variation in perceptions, likely reflecting differential experiences across operator types and geographical areas. Qualitative insights revealed that enforcement consistency is compromised by several factors: resource limitations that force risk-based prioritization, political economy considerations that may shield certain operators, geographical accessibility challenges in informal settlements, and capacity constraints that leave regulatory agencies unable to monitor all facilities with equal rigor. A NEMA officer highlighted coordination failure: *"Sometimes, two agencies will visit the same facility in the same week for different inspections, while other high-risk sites go unchecked. This is a clear case of poor coordination."* This duplication and neglect pattern reflects systemic inefficiency that undermines equitable enforcement.

These findings align with broader regional patterns documented in the literature. UNEP (2019) reported that underfunded regulatory bodies across Africa often rely on risk-prioritized inspections, leaving smaller operators unchecked for extended periods. Similarly, Agyekum et al. (2020) found that resource and staffing shortages in Ghana's petroleum sector compromised

inspection regularity and consistency. This convergence of evidence suggests that weak enforcement capacity represents a systemic barrier to disaster preparedness across resource-constrained contexts, where regulatory ambitions consistently outpace institutional capabilities.

The mandate and supervision of emergency drills by regulators scored $M = 3.88$ ($SD = 0.729$), indicating moderate effectiveness. Qualitative findings revealed that drill participation is highest when legally mandated, with 58% of respondents indicating participation in mandatory drills compared to only 27% in voluntary initiatives. A Nairobi County Disaster Management official explained: *"When collaboration is embedded in the law, every player shows up no excuses. But when it's left voluntary, some stakeholders disengage until an actual incident occurs."* This finding underscores the importance of regulatory mandate in driving compliance behaviors and suggests that voluntary approaches to preparedness are insufficient in contexts where competing priorities dilute stakeholder commitment.

Despite these challenges, evidence suggests that enforcement mechanisms do contribute materially to disaster preparedness improvements. The mean score of 4.15 ($SD = 0.665$) for the statement that enforcement has significantly improved preparedness levels indicates tangible impact. Respondents cited examples where regulatory pressure drove facility upgrades, emergency planning improvements, and enhanced safety cultures. The case of the gas distribution company that improved evacuation procedures following regulatory-mandated drills illustrates how enforcement can catalyze preparedness enhancements even when imperfectly implemented.

Role of Stakeholder Collaboration

Collaboration with agencies and partners is vital. Formal agreements improve emergency coordination and response, but challenges like overlapping roles can hinder effectiveness as shown in Table 3.

Table 3: Role of Stakeholder Collaboration in Disaster Preparedness for Energy and Petroleum-Related Incidents

Statement	Frequency (n)	Percentage (%)	Mean	SD
Organization had formal collaboration agreements with other stakeholders	172	71.8	-	-
Effectiveness of collaboration	-	-	3.84	0.91
Joint drills and information-sharing identified as key benefits	156	65.0	-	-
Delays in communication during actual incidents	115	48.0	-	-

Source: Field Data (2025)

Stakeholder collaboration emerged as a critical yet inconsistently realized pillar of disaster preparedness in Nairobi County's energy and petroleum sector. The quantitative findings revealed that 71.8% of respondent organizations had established formal collaboration agreements with stakeholders including emergency services, regulatory agencies, and industry partners. This

substantial proportion indicates widespread recognition of collaboration's importance and deliberate efforts to institutionalize cooperative frameworks. Formal agreements serve multiple functions: they establish clear expectations for roles and responsibilities, create legal foundations for resource sharing, define communication protocols, and provide mechanisms for coordinated action during emergencies. The prevalence of such agreements suggests that stakeholder collaboration has moved beyond ad hoc arrangements toward structured institutional partnerships. However, the effectiveness of these collaborations received a mean rating of 3.84 (SD = 0.91), indicating moderate satisfaction but also revealing considerable variation in experiences. The relatively high standard deviation is particularly instructive, as it signals that collaborative effectiveness is highly context-dependent, varying significantly across different partnerships, organizational types, and geographic areas. Some organizations reported highly functional collaborative relationships characterized by regular communication, joint planning, and seamless coordination during emergencies, while others described collaborations as largely ceremonial, activated primarily to satisfy regulatory requirements but lacking substantive operational integration.

Qualitative insights illuminated the factors driving this variation. A Nairobi County Disaster Management official emphasized the critical role of legal mandates: *"When collaboration is embedded in the law, every player shows up no excuses. But when it's left voluntary, some stakeholders disengage until an actual incident occurs."* This observation is empirically validated by the finding that 58% of respondents participated in mandatory collaborative drills compared to only 27% in voluntary initiatives. The stark disparity reveals that voluntary collaboration suffers from free-rider problems, competing priorities, and insufficient incentives for sustained engagement. In contrast, legally mandated collaboration benefits from enforceability, clearer accountability mechanisms, and alignment with compliance requirements that organizations cannot ignore without regulatory consequences.

The most frequently cited benefits of stakeholder collaboration were joint drills and systematic information-sharing, identified by 65% of respondents. Joint drills serve multiple preparedness functions: they test emergency response plans under realistic conditions, reveal coordination gaps before actual emergencies, build inter-organizational trust and familiarity, establish communication patterns, and provide opportunities for learning and plan refinement. The high value placed on joint drills reflects recognition that disaster preparedness is fundamentally a coordination problem requiring regular practice to ensure that multiple agencies can function as an integrated system during high-stress emergencies. Information-sharing mechanisms enable dissemination of hazard alerts, safety protocol updates, incident reports, and technical guidance across organizational boundaries, ensuring that all stakeholders operate with current, relevant information.

Yet, despite these benefits and the prevalence of formal agreements, 48% of respondents reported experiencing communication delays during actual emergencies. This finding reveals a critical implementation gap: collaborative frameworks that function adequately during planning and drills can falter under the pressure and time constraints of real incidents. Qualitative data attributed these

delays to several factors. Bureaucratic bottlenecks slow decision-making when multiple approvals are required before action can be taken. Limited crisis communication infrastructure including inadequate radio networks, unreliable mobile communications in some areas, and absence of integrated digital platforms—hampers real-time information exchange. Inadequate inter-agency coordination mechanisms mean that incident command structures may be unclear, responsibilities ambiguous, and communication channels improvised rather than pre-established.

An EPRA emergency coordinator highlighted a related challenge the absence of centralized disaster data management: *"We are collecting valuable data during inspections and incident investigations, but without a central platform, that information remains scattered across departments. We miss the opportunity to analyze patterns and improve our preventive measures."* This data fragmentation undermines collaborative learning and evidence-based improvement. When incident data, inspection findings, and risk assessments remain siloed within individual agencies, opportunities for pattern recognition, predictive analytics, and coordinated preventive interventions are lost. The survey data reinforced this concern, with 71% of respondents citing poor inter-agency coordination as a major challenge and 64% pointing to the lack of an integrated disaster data platform.

The qualitative findings also revealed that private sector motivations for collaboration extend beyond regulatory compliance. A petroleum depot safety manager explained: *"We take part in multi-agency drills not just because it's required, but because it's in our own interest. If a disaster happens and we are unprepared, the reputational and financial damage is far greater than the cost of preparedness."* This insight is supported by quantitative evidence showing that 46% of private sector respondents identified corporate social responsibility (CSR) and reputation management as key motivators for disaster preparedness investments. This convergence of regulatory, reputational, and risk management incentives creates a more robust foundation for collaboration than compliance alone would provide. Organizations that view collaboration as serving multiple strategic objectives regulatory compliance, risk mitigation, reputation protection, and social license maintenance are likely to invest more consistently in collaborative preparedness activities.

However, the findings also exposed asymmetries in collaborative capacity and commitment. Larger, more established organizations with dedicated safety departments and greater resources tend to participate more actively and benefit more substantially from collaborative frameworks than smaller operators with limited capacity. This capacity asymmetry can create imbalances where collaborative preparedness activities reflect the priorities and capabilities of dominant actors while marginalizing smaller stakeholders whose perspectives and vulnerabilities may differ significantly. Community organizations, in particular, reported feeling underrepresented in formal collaboration structures, which tend to prioritize relationships among regulatory agencies and large private operators.

The challenge of regulatory overlaps, cited by 66% of respondents, directly impacts collaborative effectiveness. When multiple agencies have overlapping mandates, confusion about leadership, duplicated efforts, and territorial disputes can undermine coordination. The NEMA officer's

observation about duplicated inspections at some facilities while others go unchecked exemplifies how coordination failures waste scarce resources and create gaps in coverage. Effective collaboration requires not merely willingness to cooperate but clear delineation of responsibilities, leadership structures, and coordination mechanisms that prevent both duplication and neglect.

These findings resonate with scholarly analyses of collaborative disaster governance. Few et al. (2007) argued that mandated collaboration ensures consistency and accountability, while voluntary approaches often falter due to weak incentives a pattern clearly evident in the Nairobi data. Moser and Satterthwaite (2008) highlighted risks of overreliance on voluntary arrangements in informal urban contexts where competing survival priorities undermine sustained engagement, a dynamic reflected in the low voluntary drill participation rates. UN-Habitat (2020) identified fragmented governance as a major weakness in urban disaster risk management, while Brown et al. (2018) documented how weak data-sharing mechanisms in East African regulatory agencies led to duplication, inefficient inspections, and reactive preparedness strategies. The Nairobi findings align closely with these broader patterns, suggesting that the collaborative challenges observed are not anomalous but reflect systemic features of urban disaster governance in resource-constrained African contexts.

Success stories do exist. Several respondents cited cases where mandated multi-agency drills led to improved emergency response times, better understanding of inter-organizational capabilities, and enhanced trust among agencies. The gas distribution company's collaboration with Nairobi County officials that improved evacuation times during a gas leak demonstrates that well-structured, practiced collaboration can deliver tangible preparedness improvements. These successes share common characteristics: legal mandates compelling participation, regular practice through drills, clear incident command structures, and organizational cultures that prioritize preparedness.

In synthesis, stakeholder collaboration represents an essential but incompletely realized component of disaster preparedness in Nairobi County. While formal agreements are widespread and joint activities valued, effectiveness is undermined by communication infrastructure deficits, coordination mechanism weaknesses, data management fragmentation, capacity asymmetries among stakeholders, and overreliance on voluntary engagement. The moderate mean effectiveness rating (3.84) and the high variation ($SD = 0.91$) indicate that collaboration's contribution to preparedness is highly variable and dependent on contextual factors including legal mandates, organizational capacity, relationship quality, and infrastructure availability. Enhancing collaborative effectiveness requires moving beyond establishing formal agreements to investing in crisis communication systems, creating integrated data platforms, clarifying coordination protocols, addressing capacity gaps among smaller stakeholders, and ensuring that collaborative frameworks are regularly tested and refined through realistic drills. The findings suggest that collaboration should be understood not as a static structural arrangement but as a dynamic capability requiring continuous investment, practice, and adaptation.

4.4 Challenges in Implementing Disaster Preparedness Mechanisms

The implementation of disaster preparedness mechanisms in Nairobi County faces interconnected challenges spanning institutional, financial, technical, and social dimensions. The most prominent challenge identified was regulatory overlaps, cited by 66% of respondents. Multiple agencies with intersecting mandates create confusion about authority, responsibility, and accountability. The practical manifestation is inefficient: some facilities undergo redundant inspections by different regulatory bodies within short timeframes, while other high-risk sites escape regulatory attention entirely. This pattern represents a coordination failure that wastes scarce resources, creates compliance fatigue among regulated entities, and leaves dangerous gaps in risk coverage.

The qualitative data vividly illustrated this problem. A NEMA officer lamented: *"Sometimes, two agencies will visit the same facility in the same week for different inspections, while other high-risk sites go unchecked. This is a clear case of poor coordination."* This testimony reveals that regulatory overlap is not merely an administrative inconvenience but a substantive threat to disaster preparedness. When coordination mechanisms fail, the regulatory system becomes simultaneously over-intensive in some areas and negligent in others, creating an uneven preparedness landscape where protection depends on location rather than risk level. The policy implication is clear: regulatory harmonization through clarified mandates, unified inspection protocols, risk-based allocation of oversight responsibilities, and coordinated scheduling could substantially improve both efficiency and coverage.

Resource constraints emerged as the second most significant challenge, with 59% of respondents identifying inadequate funding as a major barrier. Limited financial resources cascade through the preparedness system, restricting procurement of modern equipment, constraining training programs, limiting inspection frequency, reducing public awareness campaigns, and hampering emergency response capacity. The EPRA compliance officer's observation *"We have robust checklists and enforcement powers, but in practice, we can only visit so many sites each quarter. Our team is stretched thin, and without adequate transport, sometimes we can't respond as fast as we should"* captures how resource constraints translate policy intentions into compromised implementation. Even well-designed regulatory frameworks and enforcement mechanisms cannot achieve their objectives when regulatory agencies lack the fundamental resources personnel, vehicles, equipment, budgets required for consistent operationalization.

This finding carries significant policy implications. Budget allocations for disaster preparedness often reflect political priorities rather than risk assessments, with preparedness systematically underfunded relative to post-disaster response. The data suggest that governments at both national and county levels must reorient budget priorities toward preventive preparedness investments. Dedicated funding streams for inspections, equipment modernization, training programs, and public awareness campaigns would strengthen institutional resilience. Cost-benefit analyses consistently demonstrate that preparedness investments yield substantially higher returns than post-disaster expenditures, yet political economy factors including the visibility and credit-claiming opportunities associated with disaster response versus the diffuse, long-term benefits of preparedness systematically bias resource allocation away from prevention.

Skill gaps represented another critical challenge, identified by 53% of respondents. The specialized nature of energy and petroleum risks chemical hazards, electrical systems, pipeline integrity, gas explosion dynamics requires technical expertise currently in short supply. A county emergency officer articulated this constraint: *"You can have the best equipment in the world, but without trained responders, the impact is limited. We need capacity building as much as we need resources."* This observation extends beyond emergency responders to include regulatory inspectors, facility operators, community first responders, and local government officials. Disaster preparedness is fundamentally a knowledge-intensive endeavor, and capacity deficits at any point in the preparedness system create vulnerabilities that equipment and infrastructure cannot compensate for.

The adequacy of technical capacity among enforcement officers received a mean score of only 3.94 (SD = 0.701), substantiating this concern. The qualitative data revealed that many inspectors possess general safety knowledge but lack specialized training in petroleum engineering, chemical hazard assessment, or advanced risk evaluation methodologies. This capacity gap limits their ability to identify subtle compliance deficits, assess emerging risks like cyber vulnerabilities in automated systems, or evaluate the adequacy of complex emergency response plans. The policy implication points toward embedding capacity-building within disaster preparedness strategies through partnerships with universities, technical training institutions, professional associations, and international development agencies. Continuous professional development, specialized certification programs, and knowledge exchange platforms could systematically address the expertise deficit undermining effective preparedness.

Community awareness deficits emerged as a significant challenge, with 49% of respondents highlighting limited knowledge of evacuation procedures and disaster response protocols among populations near high-risk facilities. This finding reveals a fundamental preparedness gap: regulatory compliance by facilities and agencies is necessary but insufficient if the communities most exposed to potential disasters lack basic preparedness knowledge. The absence of community awareness increases vulnerability in multiple ways: residents may fail to recognize warning signs of impending incidents, delay evacuation when emergencies occur, engage in behaviors that exacerbate risks, or lack knowledge of self-protection measures that could reduce harm during disasters.

A safety officer captured this gap poignantly: *"We can't expect community preparedness if people living next to a depot have never heard of the disaster plans."* This observation underscores that disaster preparedness frameworks often privilege institutional responsibilities while treating community engagement as peripheral. Yet communities constitute the first line of response in most disaster scenarios, taking protective actions before professional emergency services arrive. Their preparedness knowledge directly determines casualty levels and disaster impact severity. The policy implication suggests that community engagement should be elevated from an optional add-on to a core component of regulatory frameworks. Structured awareness campaigns, school-based disaster education, community drills involving local residents, and risk communication embedded

within local governance structures would ensure preparedness extends beyond institutions to households and neighborhoods.

Bureaucratic delays in emergency response, cited by 45% of respondents, represented a critical operational challenge. A disaster response coordinator stated: *"In emergencies, we sometimes lose valuable time deciding on command structure instead of acting immediately."* This testimony reveals that inter-agency coordination failures and ambiguous authority structures can prove catastrophic during time-sensitive emergencies. When multiple agencies converge on an incident without pre-established incident command protocols, valuable response time is consumed in determining leadership, negotiating jurisdictional boundaries, and establishing communication channels delays that can mean the difference between contained incidents and catastrophic disasters.

The lowest mean score for prompt response to violations ($M = 3.88$, $SD = 0.761$) quantitatively validates this qualitative concern. The higher standard deviation indicates considerable variation in response times, likely reflecting differential capacity across agencies, geographic areas, and incident types. Some agencies and jurisdictions demonstrate rapid response capabilities through pre-positioned resources, clear protocols, and trained personnel, while others face logistical constraints, procedural bottlenecks, or capacity limitations that delay action. This inconsistency creates an uneven preparedness landscape where protection quality depends on location and circumstance rather than universal standards.

The policy implication is straightforward but implementation-intensive: clear incident command structures, pre-designated authority hierarchies, interoperable communication systems, regular simulation exercises, and standard operating procedures for multi-agency coordination must be established before emergencies occur. Response delays cannot be resolved during crises; they require advance preparation through institutional design, relationship-building, protocol development, and repeated practice. The finding that 48% of respondents experienced communication delays during actual emergencies despite 71.8% having formal collaboration agreements underscores that agreements alone are insufficient without accompanying operational infrastructure and practiced protocols.

These challenges do not exist in isolation but interact systemically. Regulatory overlaps are exacerbated by resource constraints that prevent effective coordination mechanisms. Skill gaps are perpetuated by inadequate funding for training programs. Community awareness deficits reflect both resource limitations for outreach campaigns and institutional prioritization that privileges regulatory compliance over public engagement. Bureaucratic delays stem from coordination failures, unclear mandates, and capacity constraints that prevent agencies from establishing robust pre-emergency protocols. This interconnection suggests that addressing implementation challenges requires integrated, systemic interventions rather than piecemeal reforms targeting individual deficits.

The findings align with broader scholarly analyses of disaster preparedness in developing contexts. UN-Habitat (2020) identified fragmented governance as a pervasive weakness in urban disaster

risk management across African cities. Brown et al. (2018) documented how weak data-sharing and coordination mechanisms in East African regulatory agencies produced duplication, inefficiency, and reactive rather than preventive preparedness strategies. UNEP (2019) reported that underfunded regulatory bodies across the continent struggle to maintain consistent enforcement, leaving systematic gaps in risk coverage. The Nairobi findings fit this regional pattern while also revealing context-specific manifestations shaped by local governance structures, resource availability, and institutional capacities.

5.0 SUMMARY OF FINDINGS

This study examined the influence of regulatory frameworks on disaster preparedness for energy and petroleum-related incidents in Nairobi County, Kenya. The findings revealed that regulatory frameworks play a central and foundational role in shaping disaster preparedness within the sector. Kenya's legislative architecture—anchored in the Energy Act (2019), Petroleum Act (2019), and National Disaster Management Policy—provides comprehensive guidelines for risk management, safety compliance, and emergency response planning. These frameworks demonstrate strong alignment with international standards from bodies such as the International Energy Agency (IEA) and the United Nations Office for Disaster Risk Reduction (UNDRR), reflecting Kenya's commitment to global best practices. Quantitative data indicated moderately high mean scores on policy adequacy, confirming that the regulatory design is conceptually sound and well-structured.

However, a significant implementation gap exists between policy formulation and operational execution. Qualitative findings exposed critical weaknesses in enforcement capacity, including inadequate funding, shortage of trained inspectors, limited technical expertise, and insufficient logistical support such as modern inspection equipment and vehicles. Bureaucratic delays and weak inter-agency coordination have resulted in fragmented enforcement and inconsistent application of safety protocols, particularly in high-risk zones where energy infrastructure is concentrated. These systemic constraints undermine the practical impact of otherwise robust regulatory frameworks.

Compliance monitoring mechanisms including periodic inspections, safety audits, and licensing requirements were identified as vital drivers of disaster preparedness, significantly improving adherence to safety protocols and reducing operational risks. However, inconsistencies in inspection schedules and delays in follow-up actions on identified deficiencies weakened their effectiveness, indicating a need for standardized, proactive monitoring approaches.

Stakeholder collaboration emerged as a significant preparedness component, with 71.8% of organizations maintaining formal collaboration agreements with emergency services, regulatory bodies, and county offices. Joint drills, simulation exercises, and information-sharing strengthened collective readiness and mutual trust, reflected in a mean effectiveness score of 3.84 (SD = 0.91). Despite these strengths, 48% of respondents reported communication delays during actual emergencies, revealing gaps between planning effectiveness and real-time execution.

Implementation challenges were diverse, encompassing insufficient funding, limited technical expertise in specialized areas, bureaucratic delays, inadequate public awareness of safety

procedures, and poor maintenance of emergency equipment. These interconnected barriers collectively diminished preparedness effectiveness and increased vulnerability of both operational sites and surrounding communities. The findings underscore that while Kenya possesses well-designed regulatory frameworks, strengthening disaster preparedness requires addressing systemic implementation deficits through increased financial investment, capacity-building programs, enhanced inter-agency coordination, improved communication infrastructure, and elevated community engagement.

6.0 CONCLUSIONS

This study concluded that Kenya's regulatory frameworks for energy and petroleum disaster preparedness, while conceptually robust and well-aligned with international standards, remain substantially constrained by critical implementation deficits. The Energy Act (2019), Petroleum Act (2019), and related legislative instruments provide comprehensive safety standards and preparedness protocols forming a solid foundation for risk management. However, these well-designed policies fail to achieve their full potential due to systemic enforcement weaknesses rooted in inadequate financial allocations, insufficient human capacity, limited technical expertise, and deficient logistical infrastructure. The gap between policy formulation and operational execution represents the most significant barrier to effective disaster preparedness.

Compliance monitoring emerged as a critical mechanism for translating regulatory requirements into operational safety improvements. Regular inspections, safety audits, and licensing requirements demonstrably enhanced adherence to preparedness standards and reduced operational risks. However, effectiveness was undermined by irregular inspection schedules, delayed follow-up on identified deficiencies, and resource constraints preventing comprehensive coverage of high-risk facilities.

Stakeholder collaboration constituted an essential pillar of disaster preparedness, with formal partnerships enabling valuable knowledge-sharing, joint training exercises, and coordinated planning that strengthened collective readiness. Despite these benefits, critical vulnerabilities persisted in real-time emergency coordination due to fragmented communication infrastructure and unclear incident command structures.

The study concluded that enhancing disaster preparedness requires holistic interventions addressing interconnected challenges: increased budget allocations, sustained capacity-building programs, streamlined inter-agency coordination, investment in modern communication technologies, elevated community engagement, and regulatory harmonization. Only through such integrated approaches can Nairobi County's energy and petroleum sector achieve resilient, effective disaster preparedness.

7.0 RECOMMENDATIONS

To strengthen disaster preparedness for energy and petroleum-related incidents in Nairobi County, policymakers should increase budget allocations to regulatory agencies such as EPRA and NEMA to enable consistent enforcement of existing regulations, including funding for regular inspections,

modern monitoring equipment, transportation, and capacity-building programs for enforcement officers (Dongmo, 2021). Regulations should be reviewed periodically to address emerging risks including cyber threats, climate-induced hazards, and technological vulnerabilities.

Regulatory bodies should adopt standardized, risk-based inspection schedules and increase audit frequency to ensure consistent oversight across all operators, with timely follow-up actions on identified deficiencies and clear accountability mechanisms to prevent recurring violations. Organizations should establish integrated communication systems and adopt digital platforms—including centralized incident reporting systems, real-time coordination dashboards, and interoperable data-sharing platforms—to improve information flow and joint decision-making during emergencies, supported by pre-established incident command structures and regular multi-agency drills. Energy companies should allocate dedicated budgets for disaster preparedness, invest in modern emergency response equipment, and implement comprehensive staff training programs, while public awareness campaigns targeting communities near high-risk facilities should be intensified to enhance community-level preparedness and response capacity (Sikder & Harvey, 2024).

7.0 FUTURE RESEARCH GAPS

Future research should examine the long-term effectiveness of regulatory reforms through longitudinal studies tracking preparedness improvements over time. Comparative studies across different counties and countries would assess the transferability of findings and identify context-specific versus universal preparedness strategies. Research incorporating perspectives from affected communities, emergency responders, and private operators would provide more holistic insights. Additionally, cost-benefit analyses of preparedness investments could quantify returns and guide resource allocation decisions, while studies on emerging risks—including cybersecurity threats to energy infrastructure and climate change impacts—would address evolving disaster landscapes.

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