

A Critical Analysis of the Regulatory Framework Governing Ghana's Commercial Explosives Sector

Original Research Article | Volume 1 | Issue 4 | 2026 | Article Number: 026

Accepted: 27 August 2026 | Published: 10 September 2026 | ISSN: 2979-8582 (Online)

 Crossref : <https://doi.org/10.67693/BJCR-5HDR5Y2X>



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Abstract

Ghana's commercial explosives sector plays a critical role in supporting mining, quarrying, construction, and infrastructure development. However, the significant safety, environmental, and security risks associated with explosives necessitate a robust and effective regulatory regime. This study evaluates the adequacy and implementation of the Minerals and Mining (Explosives) Regulations, Act 703 (Amended, 2010, 2015, 2019), identifies regulatory and operational gaps, and proposes measures to enhance governance within the sector. Adopting a mixed-methods approach, the study combined documentary analysis with survey data collected from 200 respondents representing affected communities, explosives companies, regulatory authorities, security agencies, and civil society organisations. A purposively selected subset of respondents participated in key informant interviews, while qualitative data were analysed using NVivo and word-frequency analysis techniques. The findings indicate that L.I. 2177 establishes a broadly comprehensive regulatory framework covering licensing, competency certification, manufacturing, transportation, storage, record-keeping, emergency preparedness, and disposal of explosives. Despite this, 97% of respondents perceived the existing framework as inadequate, while 96.98% advocated for stronger regulatory attention to the environmental impacts of explosives operations. Key shortcomings identified include fragmented environmental oversight, limited institutional capacity, irregular inspections, weak enforcement mechanisms, reliance on manual inventory management systems, inadequate digital traceability, insufficient emergency preparedness exercises, poor inter-agency information sharing, and ineffective controls against the diversion of explosives. The study concludes that

strengthening governance in Ghana's commercial explosives sector requires comprehensive regulatory reform. It recommends the integration of explosives-specific environmental assessment requirements, digital supply-chain tracking systems, risk-based inspection regimes, enhanced sanctions for non-compliance, improved institutional coordination, and community-centred emergency preparedness measures to promote safety, accountability, and sustainable sector management.

Keywords: Explosives, Regulation, Compliance, Enforcement, Environmental Protection, Licensing

1. INTRODUCTION

The commercial explosives industry is regulated by stringent international regulatory systems and industry best practices that are aimed at promoting safety, security, and efficiency in its operations. These frameworks focus on harmonised safety standards, classification systems, and waste operations to avert disastrous occurrences (Bermana et al., 2024). Although several attempts have been made over the years, there is no single set of standardised regulations on the regulation of explosives across the world, thus introducing huge disparities in the different national regimes. Vuorio et al. (2017) suggested that safety investigations in the commercial industry handling explosives should have a globally standardised approach since the existing rules considerably differ across nations. On the international level, several conventions, codes and guidelines guide the control of commercial explosives and explosive ordnance (Table 1). These mechanisms outline the best approaches to dealing with explosive materials safely on the international and national levels. An example is the Globally Harmonised System (GHS) of the classification and labelling of explosive chemicals used in various countries and treaties like the European ADR and International Maritime Dangerous Goods Code create strict regulations on the transportation of explosives. Organisations in the industry, such as the International Explosives Industry Group (IEIG) and the Institute of Makers of Explosives (IME), also call for consistent safety standards among nations (Biscarri, 2024).

Locally, the commercial explosive industry in Ghana is governed by the Minerals and Mining (Explosives) Regulations, 2012 (L.I. 2177) under the Minerals and Mining Act, 2006 (Act 703 as amended in 2015). The L.I.2177 integrates Environmental Impact Assessments (as per OECD/IFC standards) with operational regulations (similar to U.S./Canadian blasting codes) that mitigate environmental and safety risks (Spitz & Trudinger, 2019). However, questions remain about the effectiveness of Ghana's framework in practice. In January 2022, an explosive truck en route to a mining site exploded, killing 13 people and decimating the community of Appiatse. Investigation by an ad hoc committee revealed that the company involved in the case violated explosives storage and transport regulations, highlighting the role of the ineffective enforcement of the regulatory framework (Reuters, 2022). Similar studies have pointed to the low level of enforcement and institutional difficulties in the Ghanaian mining industry that can undermine the safety law adherence (Asumda, 2022). This situation invariably suggests a critical research gap. Thus, the degree to which the existing regulatory framework of explosives in Ghana is efficiently implemented, and to which the issues still exist, but are insufficiently comprehended.

Table 1: International frameworks governing the explosive sector

Instrument	Scope of Regulation	Primary Mechanism	Application to explosives	Compliance	Source
Globally Harmonised System of Classification and Labelling of Chemicals	Both (upstream chemicals, including explosive substances/mixtures)	Hazard classification, labelling, and SDS standards are harmonised internationally	Defines explosive hazard classes/divisions; standardises labels, pictograms and Safety Data Sheets for explosive substances and articles across sectors	Implemented through national chemical safety legislation and sectoral regulations	UNECE (2021)
European Agreement concerning the International Carriage of Dangerous Goods by Road	Both (transport of civil & military explosives by road in ADR States)	Legally binding agreement + detailed Annexes A/B covering classification, UN numbers, packaging, vehicle/driver requirements	Class 1 explosives assignment; packing instructions; segregation; vehicle construction; driver training; security plans	National transport authorities, Customs, Police	UNECE (2024)
International Maritime Dangerous Goods Code	Both (sea transport of dangerous goods, including Class 1 explosives)	Mandatory under the International Convention for the Safety of Life at Sea; detailed multimodal rules for classification, packing, segregation, stowage, and documentation	Class 1 compatibility groups; stowage/segregation; special provisions; emergency response info	Port State control/Flag State	IMO (n.d.)
International Civil Aviation Organisation's Transport of Dangerous Goods by Air	Both (air transport of dangerous goods, including explosives)	Annex 18 + Doc 9284 technical instructions; legally binding through national civil aviation rules	Forbidden/limited articles; packing instructions; quantity limits; operator/shipper responsibilities; training; security provisions	Civil Aviation Authorities' oversight and audits	ICAO (n.d.)
International Organization for Standardization (ISO) Standards (ISO/IEC 80079-34)	Civil (manufacturing/testing for equipment used in explosive atmospheres); supports safety in explosives facilities	Voluntary international standards adopted/mandated by regulators or customers; quality and conformity requirements	Quality Management System for Explosive product manufacture, testing and conformity that reduces ignition risks in explosive manufacture/storage/handling environments	Third-party certification/accreditation; regulatory referencing	ISO (2018)

Although Ghana has a detailed regulatory tool (L.I.2177), incidents and oversight issues still occur in the explosives industry, suggesting that the framework is not implemented effectively. In this regard, a systematic review of the strengths and weaknesses of the regulatory framework is justified to come up with a strategy to prevent accidents and ensure safe dealings with explosives. In relation to this gap, the study assessed the effectiveness and current regulatory regime in Ghana's commercial explosives sector; identified gaps in the regulatory framework; and proposed corrective measures to address the shortcomings of the regulatory framework and enhance general governance of the explosive industry.

2. METHODS

The research was a mixed-methods study that combined quantitative and qualitative research in a convergent research design. Such a methodological approach made it possible to analyse numerical survey data and narrative information in parallel and later synthesise them, thus enhancing the validity and richness of the resultant findings (Wallwey and Kajfez, 2023). Instead of using a controlled experimental structure, the research focused on the evaluation of real-world regulatory practice and emerging trends (Guralp, 2019). A wide group of respondents with firsthand experience of explosives regulation and utilisation was included in the target population. Respondents were drawn from employees of commercial explosives companies, and their distributors/dealers; regulators/inspectors of the corresponding agencies (the Minerals Commission, the Environmental Protection Agency); security services (the Ministry of the Interior, police, military) and other nongovernmental organisations working on disarmament or relating to mining, quarrying and construction areas. Such a varied sampling frame was aimed at capturing various views of the regulatory framework.

The stratified sampling was applied in order to represent each stakeholder group sufficiently. Bourley's Proportional Allocation formula (Achon et al., 2019) was used to ensure that every stratum was proportionally and adequately reflected in the population weight. Taro Yamen's sample size determinant formula $n = N / [1 + N (e)^2]$, with 4% precision, yielded a sample size of 200 (Table 2). For example, 65 participants were sampled within the Bogoso-Appeatse community, which had a recent explosives accident, and 42 from the Asaman community, including the Asaman Quarry, as such areas are typified by high levels of explosives usage; secondary, smaller groups were sampled within regulatory bodies and firms. Table 2 shows how the sample was distributed among different communities and institutions.

Table 2: Sample size of survey participants

Target Population	Sample Size
Bogoso-Apeate Community	65
Peabo Community (Nsawam Adoagyiri)	30
Asaman Community	42
Shai Hills/Afienya	35
Environmental Protection Agency	4
Ministry of the Interior	2
Ghana Police Service	1
Master Stone Thrower Ltd	1
Minerals Commission	2
African Explosives and Chemical Industries (AECI)	1

Asaman Quarry (second listing)	3
National Commission on Small Arms and Light Weapons	8
National Investigation Bureau	1
Ghana Armed Forces	4
Mines Advisory Group (International NGO)	1
Ghana Health Service	1
Total	200

Quantitative survey data were analysed through descriptive statistics, using percentage tables and charts. NVivo natural language and word generator were employed to develop word cloud diagrams to gain insights into open-ended questions from respondents. The word-cloud visualisation diagrams, displayed in Figures 4 and 5, were used to indicate the key concepts in the respondents' submissions to open-ended questions. Document analysis was performed using committee reports and the Minerals and Mining (Explosives) Regulation (L.I. 2177).

3. RESULTS

1. Overview of Ghana's Regulatory Framework Governing the Explosive Sector

The Minerals and Mining (Explosives) Regulations, 2012, L.I. 2177 requires that commercial explosives utilised for mining, quarrying, and civil works be regulated, excluding those used by the Police or Military. No blasting in a quarry or mining operation may occur until the Chief Inspector approves an 'explosives operating plan' (L.I. 2177) (Figure 1). Explosives may be stored or utilised solely if such activities are authorised by appropriate licences and stringent regulations (Minerals and Mining (Explosives) Regulations, 2012).

L.I. 2177 licensing provisions create a multi-level regulatory framework to achieve the objective of licensing only qualified and competent persons and entities to carry out explosives-related work. Regulations 15 to 29 provide different categories of licences, certificates of competency and permits needed in various operations in the explosives sector. One of the basic requirements is the obtaining of certificates of competency by explosives managers as well as blastmen (Regulations 15, 20, 21). At the same time, there are several business licences that are granted by the Minerals Commission regarding particular explosives operations. These are licences to buy and use explosives (Regulation 22), to store explosives (Regulation 23), to sell or broker explosives (Regulation 24), to manufacture explosives (Regulation 26), to transport explosives (Regulation 27), and to operate blasting companies (Regulation 28).

Ghana's explosives regulatory framework adheres to legal standards by ensuring licenses (Figure 1) are granted, permits are provided, and the set of documents is thorough. Specific regulations establish a comprehensive licensing procedure, where permission is required for any task involving explosives. Sub-regulation 1 of regulation 28 of L.I. states that 'a person shall not operate a blasting firm or carry out blasting activities as a contractor for a holder of a mineral right or a civil works company if that firm does not have a licence granted for that purpose by the Commission' (L.I. 2177). Besides, specialised permits for handling explosives during manufacture, sales, storage, transport, import, export, and disposal (Regulations 30-34).

Under Regulation 7 (Contravention of these Regulations), if workers continue with hazardous activities

after inspectors order them to stop, the managers of the organisation to a fine of not less than 50 penalty units and not more than 100 penalty units (i.e. 1 penalty unit is GHS12/\$1apprx.) or a term of imprisonment not less than 3 months and not more than 6 months. The L.I. 2177 considers any violation of explosives rules as a serious offence. For instance, under Regulation 8(8), a person who fails to submit an explosives plan required by this regulation and Regulation 9 is liable to pay to the Minerals Commission a penalty of \$10,000 in the first instance and an additional penalty of \$2,000 for each day the report remains unsubmitted.

The Explosives Regulation permits only companies licensed by the Minerals Commission to buy, manufacture and transport explosives, and any changes, including sales or transfers, must be reported to the Minerals Commission (Regulations 26-27). Sub-regulation 1 of Regulation 26 states that “a person shall not manufacture explosives unless that person has a license granted for that purpose by the Minerals Commission”.

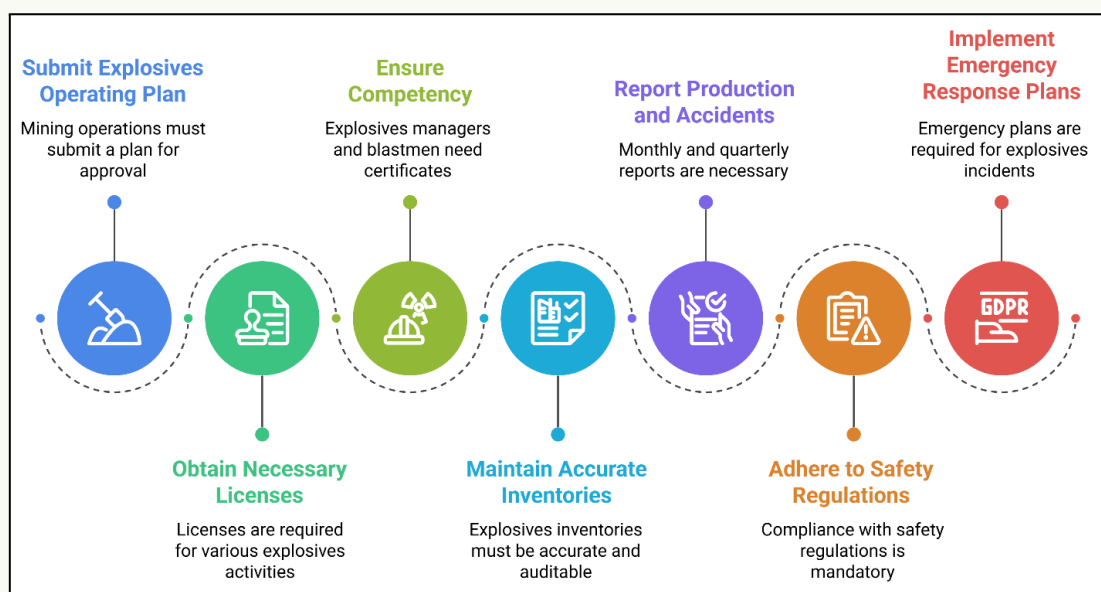


Figure 1: Overview of Ghana's explosive regulatory framework

Explosive managers are responsible for ensuring inventories are accurate and available for audit and verification. L.I. 2177 also provides that mine operators make available monthly and quarterly returns on production, accidents, diseases and environmental monitoring (Regulations 4, 25 and 47).

L.I. 2177 licensing provisions create a multi-level regulatory framework to achieve the objective of licensing only qualified and competent persons and entities to carry out explosives-related work. Regulations 15 to 29 provide for different categories of licences, certificates of competency, and permits required for various operations in the explosives sector. These are licences to buy and use explosives (Regulation 22), to store explosives (Regulation 23), to sell or broker explosives (Regulation 24), to manufacture explosives (Regulation 26), to transport explosives (Regulation 27), and to operate blasting companies (Regulation 28). While L.I. 2182 Regulation 512 ensures medical surveillance for health hazards of employees, Regulation 12 and Regulation 13 of L.I. 2177 require emergency response plans for explosives. Stating that:

...in relation to explosives for which that manager is responsible, prepare an emergency response plan which shall be included in the operating plan to be submitted to the Chief Inspector [Section 1(a)]. Section 2 (a) states that an emergency response plan shall give a description and an assessment of emergency scenarios and risks and shall include an emergency plan in relation to (i) fire; (ii) a

transportation accident involving explosives; (iii) a spill; and (iv) a detonation. The framework further makes provision for the safe disposal of obsolete or expired explosives (Regulation 69). Regulations 69, 70 and 142 (Figure 2) state that the manager responsible shall ensure that:

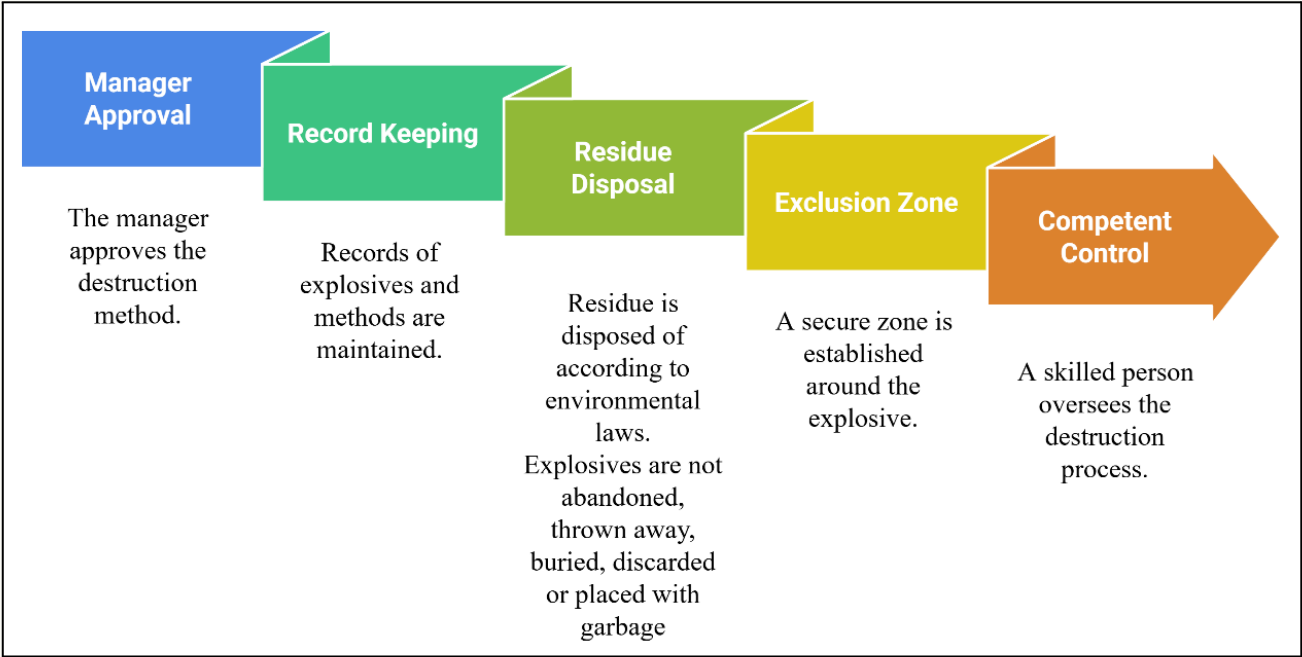


Figure 2: Explosive destruction protocols under Regulation 70 of L.I. 2177

2. Effectiveness of the Regulatory Framework in the Explosive Sector

Although Ghana has established regulations governing the explosives sector, including worker safety, transportation, and storage, there are obstacles to overcome. Whilst the survey (71.4%) acknowledged the restrictions in place, some employees (29%) in the explosives industry are not aware of these regulations.

Table 3: Existence of safety protocols in the explosive sector

Response	Frequency	(%)
<i>Awareness of regulations and safety protocols governing the industry</i>		
Yes	140	71.4
No	56	28.6
Total	196	100

The existing regulatory system overseeing the explosives sector and its associated safety standards is deemed ‘effective’ (73.2% approval as indicated in Table 4). This aligns with the stipulations of L.I. 2177, which emphasise the certification of proficient explosive handlers and the implementation of robust safety protocols in the workplace, including the utilisation of protective gear, routine inspections, and accident reporting mechanisms (Regulations 3, 60, 141, 199 of L.I. 2177). Though weak, enforcement seemed to be frequent, with 38.4% of respondents in the explosive sector indicating they undergo routine inspections monthly, and 33.8% reporting checks occurring every ten months or more. On the issue of adequacy,

52.3% believed the regulatory procedures are sufficient, whereas 5% expressed strong agreement. Nonetheless, 40% maintained a neutral stance, indicating ambiguity and the need for enhanced communication and enforcement strategies.

Table 4: Effectiveness and enforcement of the regulatory framework

Response	Frequency	(%)
<i>Effectiveness of the regulatory framework</i>		
Very effective	6	3
Effective	145	73.2
Neutral	42	21.2
Ineffective	4	2
Very ineffective	1	0.5
Total	198	100
<i>Frequency of enforcement of the regulatory framework</i>		
Monthly	76	38.4
10 months and above	67	33.8
6–9 months	26	13.1
2–5 months	16	8.1
No idea	8	4
Rarely/never	5	2.5
Total	198	100
<i>Sufficiency of the regulatory framework and its safety protocols</i>		
Strongly agree	11	5.5
Agree	104	52.3
Neutral	79	39.7
Disagree	5	2.5
Total	199	100

3. Gaps in the Regulatory Frameworks of the Explosive Sector

The findings of the study (Figure 3) show that 97% of respondents (171 Agree; 21 Strongly Agree) hold that the existing Minerals and Explosives regulatory measures in Ghana have limitations; only 3% (6 Disagree) say otherwise. This mass affirmation that is negative indicates some level of mistrust of explosive regulations. Notwithstanding, it is significantly endorsed by 96.7% of respondents that Ghana's minerals and explosives regulatory frameworks should prioritise the environmental effects of explosives. However, 3.3% discerned otherwise (Figure 3). Collectively, these results imply robust sector-specific support in more than just the existing environmental protection, but even stricter and ecologically oriented regulatory control on explosives management in Ghana.

Table 5: Regulatory limitations and environmental priorities

Response	Frequency	(%)
<i>Do mineral and explosives frameworks have limitations?</i>		
Strongly Agree	21	10.6
Agree	171	86.4
Disagree	6	3.0
Total	198	100
<i>Should regulation prioritise the environmental effects of explosives?</i>		
Yes	193	96.7%
No	7	3.3%
Total	200	100

In consonance with the above results, content analysis of the Minerals and Mining (Explosives) Regulations, though Regulations 2012, LI 2177 provides detailed guidance; however, some gaps have been identified under the main tenets of the regulation. Areas such as transportation, storage, enforcement, emergency, compliance, inventory/returns, end-user certificate and tracing, sanctions, diversion and trafficking (Table 6). These may undermine the effectiveness of the country's explosive regulatory framework.

Regulations 2, 3, and 14 delineate the inspection powers and responsibilities of Inspectors, encompassing seizure, inquiry, and cessation orders. Nonetheless, insufficient logistics (monitoring vehicles), inadequate personnel, and the lack of inter-agency coordination presently hinder the Minerals Commission's capacity to ensure that explosive companies comply with the stipulations of L.I. 2177 (Table 6). Furthermore, concerning the mechanism to prevent the diversion of commercial explosives, Regulations 4 and 62 fail to offer adequate measures due to the absence of an anti-trafficking mechanism. This may impact illegal trafficking and diversion of explosives, posing security threats as these materials are utilised in improvised explosive devices for terrorist activities.

Table 6: Gap Analyses of the Minerals and Mining (Explosives) Regulations, 2012 (L.I. 2177)

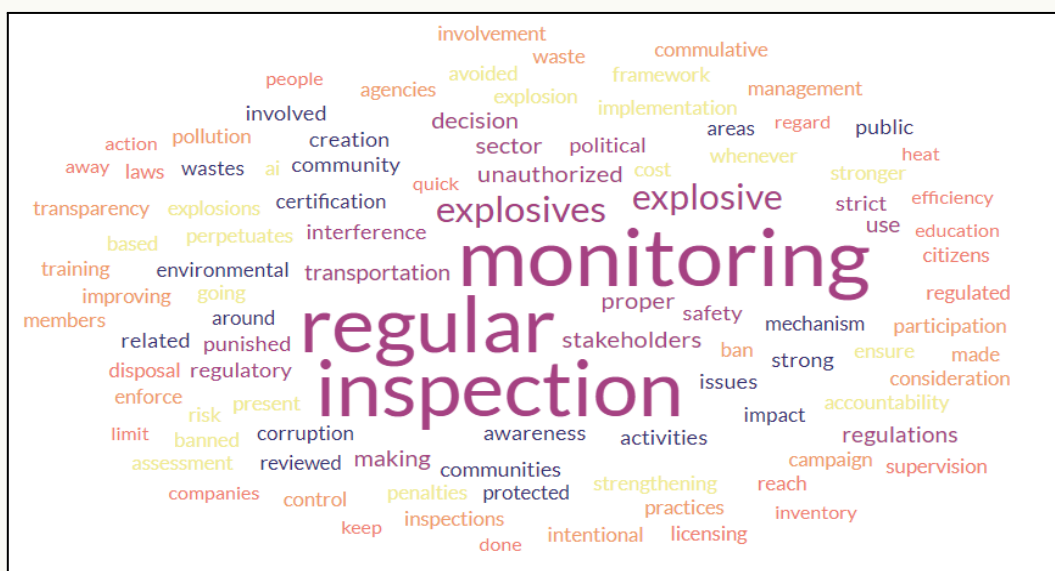
Thematic Area	Provisions in L.I. 2177	Identified Gaps
Transportation	Regulations 95-115 outline acceptable types of vehicles, routing policies, escort requirements, time restrictions, the necessary documentation and emergency procedures.	GPS-based real-time tracking and connectivity to digital monitoring systems related to high-risk consignments are lacking.
Storage	Regulations 130-168 provide requirements for surface and underground magazines, security,	Limited provisions on automated inventory systems

	inspection, and separation of detonators and explosives.	or digital surveillance for remote monitoring.
Enforcement	Regulations 2, 3 and 14 defined inspection powers and responsibilities for Inspectors, including seizure, inquiry, and orders for cessation.	Inadequate enforcement logistics (manpower, transport); absence of inter-agency enforcement coordination.
Emergency	Regulations 13, 56–59 mandate emergency response plans covering fire, detonation, accidents, and coordination centres.	No mandatory simulation drills or community-based awareness; review of plans only post-incident.
Compliance	Regulations 6, 8–11 and 50 require adherence to approved operating plans, safe work practices, and training; they include penalties for non-compliance.	Weak auditing mechanisms and a lack of third-party verification of compliance; no compliance incentive schemes.
Inventory/Returns	Regulations 46–47 required monthly returns on imports/exports, sales, losses, and incidents. Availability of multiple inventory books is required.	The inventory process is manual. Thus, there is an absence of a national and integrated explosive database management platform.
End-User Certificate and Tracing	Regulations 44–45 require unique IDs, tracking through the supply chain, and tracing records on explosives; however, no reference to End-User Certificates.	No End-User Certificates mechanism; tracing is limited only to physical labels and records, which are prone to forgery and poor documentation.
Sanctions	Regulation 7 defines sanctions between units of penalties and imprisonment, though the few offences receive less punitive treatments, and some jurisdictions do not provide the means to discourage the offender.	The financial fines that apply are not proportional to the intrinsic risk of the offences, nor to provide a graduated penalty to recidivists.
Diversion and Trafficking	Regulations 4 and 62 require the recording of theft or loss and its tracking.	It lacks diversion monitoring systems; an anti-trafficking mechanism is not in place, and there is no formal coordination across borders.

4. Addressing Gaps of the Explosive Regulatory Framework in Ghana

In their open-ended responses and interviews, participants not only pointed out problems but also strongly emphasised several key areas for reform in Ghana's explosives regulatory regime. These suggestions are

Furthermore, words related to governance issues: “*corruption*,” “*political influence*,” and “*incompetence*”, featured in Figure 4, suggest that respondents suspect malpractice and lack of political will are undermining effective oversight. Many participants advocated for improved training of personnel and greater transparency in regulatory processes, as well as better inter-agency cooperation (for example, coordination between the Minerals Commission, EPA, Police, and Disaster Management agencies) to ensure that explosives are handled and monitored properly across all stages.



(larger words indicate more frequent mentions of that concept by respondents).

When asked specifically about what aspects of the regulatory framework most urgently need revision, respondents gave clear priorities (Figure 5). The “licensing”, “certification”, and “enforcement” provisions were the top concern. Several respondents felt the licensing process should be more rigorous and that enforcement of license conditions must be tightened. Another major theme was addressing “*unauthorised use*” and “*weak compliance*”. Respondents noted that outdated regulations and political interference have allowed unsafe practices to continue, and thus called for updating the laws and eliminating undue influence. The “*transportation*”, “*storage*”, and “*disposal*” of explosives were also commonly mentioned as needing stricter guidelines to reduce hazards (reflecting recent accidents involving transport). Some of the respondents urged strengthening “penalties” and “emergency preparedness” provisions: they believe current penalties do not sufficiently deter negligence, and that mandatory emergency response drills and clearer community evacuation procedures should be established. Finally, respondents highlighted the importance of protecting local communities and involving them in decision-making, as well as ensuring continuous education for all handlers of explosives. Overall, there was even a sentiment among some respondents for a “*comprehensive overhaul*” of the regulatory framework, essentially calling for a new or

significantly amended legislation to replace L.I. 2177. This is to help achieve a higher level of safety, efficiency, and transparency in the explosives sector.

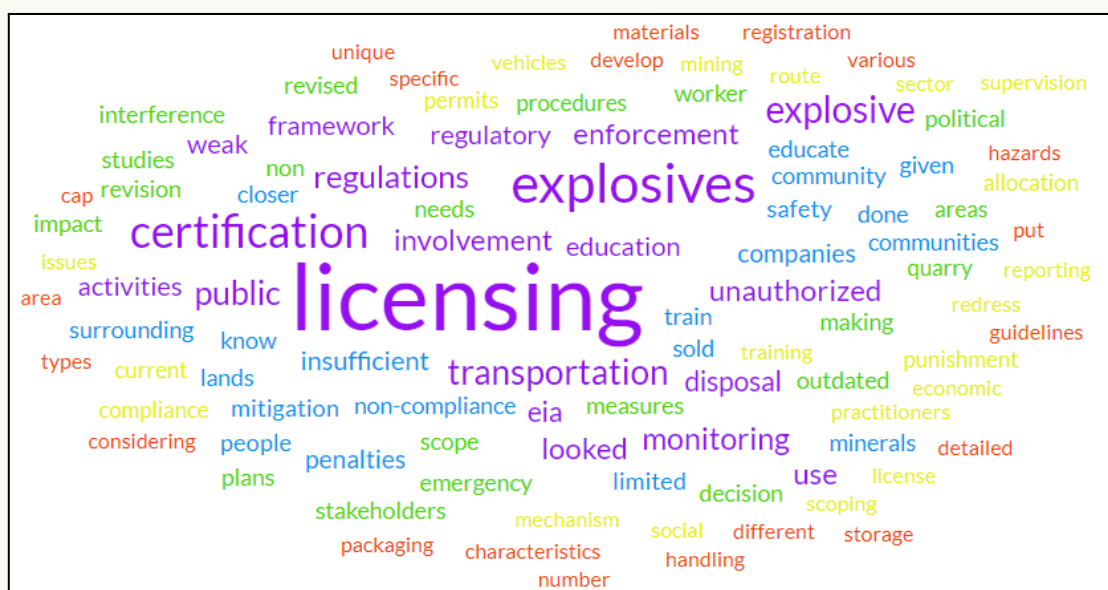


Figure 5: Word cloud highlighting the areas of the explosive regulatory framework that respondents believe require urgent revision.

4. DISCUSSIONS

The above analyses reveal the paradox in the explosives regulatory framework in Ghana. On the one hand, the regulatory framework may be seen as strong and consistent with the international standards. For instance, under Regulation 15(4[a&b]) of the L.I. 2177, explosives managers and handlers must obtain certificates or permissions, as is usual in other countries within the mining sector (Komey, 2022). The IFC guidelines, for instance, emphasise maintaining material safety data sheets and incident logs for all hazardous materials. Regulations in countries, such as Canada and Australia, on explosives also require specific blast documentation and incident reporting (Bae et al., 2025; Hu et al., 2024). In line with global standards, the transaction permits under Regulations 22-24, 26, and 28 of L.I. 2177 give the Minerals Commission of Ghana to increase its traceability and accountability efforts of explosive materials within the supply chain, in conjunction with international recommendations on explosives tracking and management (UN SaferGuard, 2015).

On the other hand, empirical studies reveal that there are significant loopholes in the components of non-enforcement that significantly diminish their efficiency. Though L.I. 2177 has regulations which take care of environmental issues like the prevention of pollution and vibration control (Regulations 198 and 199), nevertheless, the environmental protection in L.I. 2177 is limited in scope compared with international best practice. The regulation fails to comprehensively incorporate the EIA-specific to explosives use into the licensing and permit regimes (Boahen et al., 2024). As explosives pose notable environmental hazards, such as habitat destruction, water contamination, and air pollution, the lack of a sound environmental integration in L.I. 2177 leaves regulatory gaps that hinder sustainability. Also, there is a lack of coordination between the Minerals Commission and the EPA, which, in many cases, leads to a fragmented oversight of explosives-related environmental risks, making it difficult to manage them holistically (Adranyi et al., 2024). Though L.I. 2177 establishes requirements concerning the personal protective equipment, training, and safety officers (Regulations 50, 52, 60), literature reveals gaps in the safety practices throughout the explosives industry in Ghana. The risk of injuries and long-term diseases is

still high because of the insufficient safety culture, lack of supervision, and fewer periodic medical checks (Abdalla et al., 2017).

Among the gaps in L.I. 2177 are the mechanism of enforcement and compliance (Table 3). Though the regulation grants wide oversight powers to the inspectors (Regulations 3, 14 and 14), empirical evidence has noted that the low institutional capacity, insufficient logistic support, and shortage of personnel are spoilers of the regulatory enforcement (Asumda, 2022). The Minerals Commission and Chief Inspector of Explosives are usually ill-equipped and staffed to conduct thorough inspections, especially in the remote mining sites (Adu-Gyamfi et al., 2017). Because of this, the compliance checks are not always regular, and the non-observance of safety procedures may pass unmonitored. Equally, the current sanction framework, composed of fines and imprisonment (Regulation 7), is not always the deterrence that is needed by large-scale operators who might view penalties as operational costs (Timbonga, 2023).

Companies are obliged by the regulation to have emergency response plans (ERP) (Regulation 13), although research indicates that a significant percentage of the plans are generic and may not be detailed enough to handle complicated on-site emergencies, such as large-scale detonations or multiple casualty incidents (Amponsah-Tawiah et al., 2016). This disparity is notably high in the communities adjacent to mining, quarry, and construction sites, where the explosions may cause severe off-site consequences. According to Mensah et al., emergencies such as accidents are examples of instances where there are documents and processes, but they are rarely effective in practice. Without proper monitoring and responsibility, the L.I. 2177 cannot be more than a standard process requirement (Mensah & Amoah, 2024).

The recordkeeping and reporting (Table 3) remain mostly manual (Regulations 46 and 47), even though the worldwide tendency is towards the digitalisation of explosive management systems to increase transparency and real-time monitoring (Boahen et al., 2024). There is a lack of requisite digital tracking to enable traceability throughout the explosive supply chain so that regulators can have trouble conducting swift audits or forensic investigations in the event of diversion or an accident. Even though L.I. 2177 includes detailed security requirements (Regulations 12, 62, 64), the risk of diversion and theft of explosives is a serious issue to consider due to insecurities in the region and the spread of explosives. Weak tracking systems, lack of coordination with national security agencies, and deplorable data sharing have been discovered as key vulnerabilities by scholars (Chelin & Els, 2020).

5. CONCLUSION

The paper reveals that despite the well-developed grounding that the regulatory framework provides to Ghana's explosive sector, there remain some gaps that limit its effectiveness. Notwithstanding, the regulatory framework corresponds to the internationally recognised standards regarding licensing, safety measures, transportation logistics, storage regulations, and preparedness for emergencies. However, weaknesses in environmental integration, digital traceability of explosives, and ineffective enforcement and diversion control measures undermine holistic regulation.

To this end, strengthening Ghana's explosive governance requires a comprehensive regulatory reform with a focus on digitalisation, stricter enforcement, improved safety culture, and robust interagency cooperation. It is also critical to ensure provisions on community protection, community awareness on the dangers of explosives, training, and modernised licensing systems should be enshrined in the future amended regulatory framework. Addressing these gaps will not only align Ghana's regulatory framework on explosives with evolving global best practices but also ensure a safer, more sustainable, and accountable explosives industry that supports the country's development priorities, especially in the extractive sector.

The study provides an empirical and legal assessment of a security-sensitive, under-researched sector. It connects stakeholder evidence with regulatory gap analysis and identifies practical reform priorities, including explosives-specific environmental assessment, integrated digital tracking, risk-based enforcement, community protection and institutional coordination. Future studies should undertake comparative assessments of compliance across mining, quarrying, construction and transport operations; measure occupational, ecological and community outcomes; and evaluate the effectiveness of digital traceability.

- **Funding:** No funding was received for this study.
- **Conflict of Interests:** The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.
- **Ethics Approval:** The study received ethical approval from the Committee for Human Research and Ethics, University of Energy and Natural Resources, Sunyani (Reference No.: CHRE/AP/473/024). All participants were provided informed consent before the data collection.
- **Use of AI:** To improve this paper's language and grammar, QuillBot was used concurrently.

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