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| RESEARCH ARTICLE

Case Accuracy for Offshore Assets Using the Nkansah Reconciliation Model: Technical Report & Case Study

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| ABSTRACT
The paper is a technical report and a case study that explores the use of the Nkansah Reconciliation Model (NRM) to improve the accuracy of the offshore oil and gas industry in Ghana and the case study of the Saltpond production platform. Methane emissions consistently represent a significant challenge to climate and governance and inconsistencies between operator-reported information and remote sensing measurements have led to uncertainty in Environmental, Social, and Governance (ESG) disclosures. The paper records how Kumi and associates Engineering used the NRM to reconcile these data sources using atmospheric correction with source specific validation as well as statistical weighting. The outcomes included the elimination of reporting differences (45 percent to less than 8 percent), identification of three super-emitters that contributed over 60 percent of total emissions, and the planning of a cost-effective abatement program that was estimated to decrease the emission by more than half. Benchmarking further depicted the strength of the NRM in contextual flexibility, accuracy, and acceptability by the stakeholders as compared to international reconciliation models. The results highlight the twofold advantage of environmental integrity and performance efficacy, which make the NRM a revolutionary instrument of regulators, operations, investors, and civil societies. The authors find that institutionalizing the model in the Ghanaian framework of regulating methane could not only enhance the national standards of reporting, but also, would make a blueprint to other African countries with a great amount of resource base to find a balance between energy development and environmental responsibility.

| KEYWORDS
Methane emissions, Nkansah Reconciliation Model, offshore oil and gas, environmental governance, Saltpond platform, Ghana, ESG reporting, data reconciliation

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1. Introduction & Project Scope
In the fourth quarter of 2024, Kumi & Associates Engineering (KAE) was engaged by Springfield Exploration & Production (E&P) Ghana to undertake an independent audit of methane emissions associated with the Saltpond offshore production platform. This mandate was not simply a routine compliance exercise; rather, it reflected Springfield's broader commitment to environmental transparency, corporate accountability, and alignment with Ghana's evolving climate and energy governance frameworks. Of particular relevance was the Methane Roadmap released by Ghana's Environmental Protection Agency (EPA) in mid-2024, which introduced a suite of policy instruments and reporting expectations designed to enhance methane management across the oil and gas sector.

The Saltpond platform, one of Ghana's oldest offshore production assets, occupies a symbolic and strategic place in the nation's energy history. Originally commissioned in the 1970s, the facility has undergone numerous operational upgrades over the past decade to extend its productive lifespan and to incorporate improved safety and efficiency systems. However, despite these investments, its emissions monitoring and reporting protocols remained heavily reliant on conventional estimation methods, largely based on engineering calculations and emission factors rather than direct measurement or advanced modeling. While such methods were acceptable under earlier national and international standards, they are increasingly regarded as insufficient within the context of modern Environmental, Social, and Governance (ESG) disclosure requirements and climate accountability frameworks.

Against this backdrop, Springfield sought to validate and strengthen its internal emissions inventory through an independent third-party verification process. The objective was to reconcile discrepancies that had emerged between Springfield's own bottom-up inventory estimates and satellite-based top-down assessments conducted by international monitoring initiatives. Reconciling these conflicting datasets was essential not only for regulatory compliance but also for enhancing the credibility of Springfield's public reporting and for informing its long-term methane abatement strategy.

To achieve this, KAE applied the Nkansah Reconciliation Model (NRM), a Ghana-specific data harmonization framework developed to address the unique atmospheric, operational, and infrastructural conditions of offshore oil and gas installations in the Gulf of Guinea. Unlike generic international models, the NRM incorporates localized meteorological variables such as prevailing trade winds, humidity fluctuations, and temperature inversions common to the Gulf region, all of which can distort methane plume dispersion and complicate remote sensing accuracy. The model also integrates operational variables unique to legacy platforms like Saltpond, where intermittent venting, flaring inefficiencies, and equipment degradation can produce irregular and difficult-to-quantify emissions patterns.

The scope of this project, therefore, extended beyond a narrow verification exercise. It encompassed the development of a robust emissions baseline for the Saltpond facility, constructed through a triangulation of internal Springfield records, remote sensing data, and direct field measurements. By applying the NRM framework, KAE aimed to generate a high-confidence emissions profile that would withstand both regulatory scrutiny and investor due diligence. Importantly, the project also sought to identify priority areas for emissions mitigation, thereby contributing to Springfield's broader decarbonization agenda and to Ghana's national commitments under the Global Methane Pledge, to which the country became a signatory in 2022.

This case study documents the technical processes, challenges, and outcomes encountered during the audit. It illustrates not only the methodological innovations applied but also the institutional and governance dynamics at play as Ghana transitions toward a more transparent and scientifically grounded methane reporting regime. By situating the Saltpond audit within this broader policy and operational context, the study provides insights into how legacy oil and gas assets in West Africa can adapt to rising ESG expectations while contributing to global climate objectives.

2. Contextual Background: Methane Governance in Ghana

Methane emissions have increasingly become a central issue in Ghana's evolving environmental policy agenda, reflecting the country's recognition of methane as a highly potent greenhouse gas with a global warming potential far exceeding that of carbon dioxide over a 20-year horizon. Ghana's commitment to addressing this challenge was underscored in 2023 when the government formally endorsed the Global Methane Pledge (GMP), an international initiative aimed at cutting global methane emissions by at least 30% by 2030 relative to 2020 levels. By aligning itself with this pledge, Ghana not only signaled its dedication to contributing to global climate mitigation efforts but also acknowledged the domestic environmental and public health benefits that effective methane management could yield.

Following the endorsement of the pledge, the Environmental Protection Agency (EPA) of Ghana developed and launched a sectoral roadmap that outlines ambitious yet targeted strategies for methane reduction. The roadmap prioritizes three major methane-intensive sectors: oil and gas, agriculture, and waste management. Each of these sectors presents distinct challenges and opportunities for emission reduction. In oil and gas operations, fugitive emissions from equipment, flaring inefficiencies, and venting during maintenance activities remain persistent concerns. In agriculture, methane arises primarily from enteric fermentation in livestock and anaerobic decomposition of organic matter in rice paddies. Meanwhile, waste management contributes significantly through emissions generated from unmanaged landfills, open dumping, and inadequate waste treatment facilities.

A critical component of the EPA's roadmap is the enhancement of measurement, reporting, and verification (MRV) protocols. Accurate MRV systems are indispensable for understanding the magnitude, distribution, and sources of methane emissions. However, achieving high-quality data collection has proven complex, especially in Ghana's oil and gas sector. Offshore production platforms, which operate under humid and high-salinity conditions in the Gulf of Guinea, pose unique technical and logistical challenges for methane quantification. Traditional estimation methods such as the reliance on generic emission factors, periodic inspections, and handheld leak detection equipment tend to miss intermittent or spatially diffuse emissions. These limitations not only result in systematic underreporting but also lead to misaligned abatement strategies that may fail to capture the most significant emission sources.

Recognizing these challenges, the EPA commissioned a series of technical studies aimed at developing innovative solutions to strengthen methane governance. One notable outcome of this initiative was the development of the *Nkansah Reconciliation Model*. Named after environmental systems analyst Christopher Nkansah, this model represents a pioneering effort to refine Ghana's methane accounting framework. The model integrates multiple data streams by combining atmospheric correction algorithms, source-specific cross-validation, and statistical weighting techniques. Through this process, disparate datasets from ground-based measurements, remote sensing technologies, and sector-specific inventories can be reconciled to generate a unified and more reliable emissions profile.

The Nkansah Reconciliation Model is particularly significant for Ghana's oil and gas sector, where emission heterogeneity is most pronounced. By enabling more accurate detection and quantification of both continuous and episodic releases, the model reduces uncertainties that previously hindered regulatory oversight and targeted interventions. Furthermore, its methodological design reflects a balance between international best practices and local operational realities, ensuring that the framework remains both scientifically robust and practically implementable within Ghana's institutional and technical capacities.

Beyond its immediate technical contributions, the adoption of the Nkansah Reconciliation Model carries broader governance implications. It strengthens transparency and accountability in environmental reporting, thereby bolstering Ghana's credibility in meeting its international climate commitments under the Global Methane Pledge. Additionally, the model lays the groundwork for cross-sectoral coordination, as accurate emissions profiles can inform policy decisions ranging from regulatory enforcement in oil and gas operations to the design of methane capture systems in waste management facilities and the promotion of climate-smart practices in agriculture.

In summary, Ghana's approach to methane governance reflects a forward-looking strategy that combines international alignment with local innovation. By endorsing the Global Methane Pledge, establishing a comprehensive sectoral roadmap, and developing cutting-edge tools such as the Nkansah Reconciliation Model, Ghana is positioning itself not only to reduce its methane emissions by 30% by 2030 but also to emerge as a regional leader in methane governance across Africa. This integrated approach underscores the country's recognition that effective methane management is not merely an environmental imperative but also an opportunity for sustainable economic development, public health protection, and climate leadership.

3. The Challenge: Reconciling Disparate Data Sources

Springfield presented KAE with two primary datasets for the methane emissions analysis, each derived from distinct collection methods and institutional mandates.

Operator Data. The first dataset consisted of high-flow sampling measurements and detailed component-level Leak Detection and Repair (LDAR) logs compiled by Springfield's internal Health, Safety, and Environment (HSE) team. This data was obtained using calibrated instruments in accordance with the Ghanaian Petroleum Commission's *Environmental Monitoring Guidelines*. The operator's dataset provided a granular view of emissions at the component level valves, compressors, seals, and other infrastructure where leaks were identified, measured, and recorded. Because the collection process followed established regulatory protocols, Springfield considered this dataset reliable, auditable, and directly defensible in the context of compliance reporting. It also reflected the company's long-standing internal practices for quantifying emissions, which were geared toward operational maintenance and regulatory obligations rather than external scrutiny from investors or ESG rating agencies.

Remote Sensing Data. The second dataset originated from a third-party contractor specializing in aerial emissions monitoring. Over a three-day period in October 2024, the contractor deployed Optical Gas Imaging (OGI) equipment mounted on a low-flying aircraft. This approach captured wide-area imagery of Springfield's operational footprint and applied infrared spectral analysis to estimate methane plume concentrations and volumes. Unlike the operator data, which was site-specific and bottom-up in nature, the remote sensing data adopted a top-down perspective, offering a broader snapshot of emissions dispersed across facilities. The resulting dataset included both raw imagery and quantified plume estimates, thereby introducing an additional layer of interpretation and modeling.

At first glance, both datasets seemed credible, each supported by established methodologies. However, when subjected to comparative analysis, a substantial discrepancy emerged. The OGI-based dataset reported methane volumes that exceeded operator-reported figures by nearly 45%. This divergence was not a marginal statistical difference but a gap large enough to challenge the integrity of Springfield's emissions accounting framework.

The implications of this discrepancy extended beyond a technical debate. For Springfield, the accuracy and defensibility of emissions data directly shaped its Environmental, Social, and Governance (ESG) disclosures. Investors, regulators, and civil society stakeholders increasingly demanded transparent and verifiable methane accounting, especially given the global focus on methane as a high-impact greenhouse gas. Any indication that Springfield's internal reports underestimated emissions risked undermining trust, inviting regulatory penalties, and damaging the company's reputation. Conversely, adopting the higher remote-sensing figures without careful scrutiny could unfairly inflate Springfield's reported footprint, potentially eroding competitiveness and exposing the company to costly mitigation obligations.

The challenge, therefore, was twofold. First, Springfield and KAE had to assess whether the operator's ground-based, protocol-driven measurements systematically undercounted emissions—perhaps missing intermittent, large-scale releases not captured during routine LDAR inspections. Second, they needed to determine whether the OGI survey had overestimated plume volumes, given the known limitations of aerial infrared techniques, such as sensitivity to weather conditions, atmospheric interference, and assumptions in plume dispersion modeling.

Reconciling these disparate data sources required more than statistical adjustments. It called for a comprehensive methodological alignment, integrating the strengths of both bottom-up and top-down approaches while accounting for their inherent limitations. Without such reconciliation, Springfield risked submitting ESG disclosures that lacked the evidentiary robustness required for regulatory approval and stakeholder confidence.

In short, what initially appeared as a straightforward comparison of two emissions datasets quickly evolved into a complex analytical and governance challenge. The 45% gap was not just a numerical inconsistency; it represented the intersection of scientific uncertainty, regulatory compliance, corporate accountability, and the broader geopolitics of methane management in Africa's energy sector. Successfully navigating this challenge would demand technical rigor, transparent methodologies, and a willingness by Springfield to confront the uncomfortable possibility that its historical emissions reporting practices required significant recalibration.

4. Methodology: Application of the Nkansah Reconciliation Model

To address the persistent conflict between operator-reported data and Optical Gas Imaging (OGI) measurements, KAE's analytical team applied the Nkansah Reconciliation Model (NRM). This model was selected for its tailored applicability to Ghana's offshore oil and gas conditions, where unique meteorological and oceanic variables significantly influence measurement accuracy. Unlike conventional reconciliation methods that rely on rigid statistical adjustments, the NRM integrates heterogeneous datasets ranging from infrared imagery and direct sampling to operator logs into a unified and transparent emissions narrative. By doing so, the model not only bridges discrepancies but also provides a defensible framework for regulatory compliance, operational decision-making, and long-term environmental monitoring.

4.1 Atmospheric Correction

The first stage of the reconciliation process involved correction of the OGI data for atmospheric distortions. Offshore platforms exist in highly dynamic environments where elevated humidity, fluctuating wind speeds, and saline sea spray can significantly degrade the accuracy of infrared imaging. These environmental interferences often produce exaggerated plume signatures, which can misrepresent actual methane and hydrocarbon emissions.

Using proprietary algorithms embedded in the NRM, KAE conducted a three-pronged atmospheric correction process:

- **Humidity Index Calibration:** Spectral absorption coefficients were dynamically adjusted using real-time humidity readings collected from on-site sensors. This step ensured that excessive water vapor did not artificially amplify the apparent density of gas plumes.
- **Sea Spray Attenuation:** Saline aerosols, common in offshore atmospheres, were identified and filtered out to prevent false plume detections. This was achieved through particle dispersion modeling that distinguished hydrocarbon molecules from salt particles.
- **Thermal Drift Compensation:** Offshore installations are subject to fluctuating temperature gradients between the sea surface, air layers, and equipment. These variations can distort plume visibility. Normalization procedures were applied to account for thermal drift, ensuring that plume boundaries were consistent and reliable.

The implementation of these corrections reduced the initially inflated emission estimates in the OGI dataset by approximately 28%, aligning the adjusted figures much more closely with operator-reported emissions. This reduction demonstrated the critical role of atmospheric correction in preventing systematic overestimation.

4.2 Source-Specific Cross-Validation

Rather than relying solely on aggregate comparisons, the NRM emphasizes source-level reconciliation. This step required mapping each corrected OGI plume to corresponding equipment components documented in the Leak Detection and Repair (LDAR) logs. The process was executed through three integrated sub-tasks:

- **Spatial Overlay Analysis:** Geographic Information System (GIS) tools were used to overlay OGI plume coordinates on detailed platform schematics. This ensured that emissions were not generalized across the facility but instead linked to precise valves, seals, flanges, or compressor units.
- **Temporal Matching:** Time-stamped OGI detections were cross-referenced against operational and maintenance logs. This matching was crucial for distinguishing transient emissions, such as those caused by venting events, from persistent leaks.
- **Component Attribution:** Once spatial and temporal consistency was established, emissions were attributed to discrete equipment components. This enabled differentiation between high-frequency leak points (e.g., valve seals) and less common but higher-volume sources (e.g., pressure relief devices).

Through this granular validation process, the team was able to verify both datasets while highlighting areas of convergence and divergence. Importantly, it allowed for diagnostic insights identifying systemic issues, such as recurring flange leaks, which could be prioritized for corrective maintenance.

4.3 Statistical Weighting

The final reconciliation stage involved applying the model's statistical weighting framework to balance the inherent strengths and weaknesses of each data source. Rather than treating all measurements as equally valid, the NRM assigned confidence scores based on three key parameters:

- **Measurement Methodology:** Direct sampling and calibrated sensor data were given higher weights relative to remote sensing techniques such as OGI, which, while useful for detection, are more prone to environmental interference.
- **Instrument Calibration History:** Datasets generated by recently calibrated instruments received priority weighting, ensuring that measurement drift did not compromise reconciliation outcomes.
- **Environmental Stability:** Observations recorded under stable atmospheric conditions such as periods of low wind variability and consistent humidity—were ranked higher than those taken during unstable conditions.

By integrating these weighted scores, the NRM produced a composite emissions profile that balanced the need for precision (ensuring individual measurements were trustworthy) with the need for coverage (ensuring all potential sources were represented). This statistically robust approach generated a reconciled emissions inventory that was both technically defensible and operationally useful.

The structured application of the Nkansah Reconciliation Model enabled KAE to systematically resolve discrepancies between reported and observed emissions data. Through atmospheric correction, source-specific cross-validation, and statistical weighting, the model delivered an emissions narrative that accounted for environmental complexities, validated operator logs at the component level, and synthesized multiple datasets into a reliable composite profile. This methodology not only enhanced confidence in emissions reporting but also provided a replicable framework for future monitoring across Ghana's offshore sector.

5. Results & Quantified Impact

The application of the Nkansah Reconciliation Model to Springfield's methane emissions data produced several significant and quantifiable outcomes. These results demonstrate not only the robustness of the model in addressing data inconsistencies but also its ability to identify critical emission sources and inform cost-efficient abatement strategies. Overall, the model's deployment offered Springfield a high-confidence baseline for environmental, social, and governance (ESG) reporting, regulatory compliance, and operational planning.

5.1 Reduced Uncertainty

One of the most immediate impacts of the reconciliation process was the substantial reduction in data uncertainty. Initially, Springfield's two primary datasets derived from satellite-based remote sensing and on-site sensor networks showed a discrepancy of approximately 45%. Such a large gap undermined confidence in the company's emissions reporting and raised concerns about the accuracy of regulatory submissions. After applying the Nkansah Reconciliation Model, this discrepancy was reduced to less than 8%.

This level of convergence is particularly significant for two reasons. First, it provided Springfield with a credible, auditable emissions baseline that could withstand regulatory scrutiny and align with global ESG reporting standards. Second, it allowed internal stakeholders including engineers, sustainability officers, and financial controllers to plan with greater certainty. The improved confidence in the data enabled Springfield to shift from reactive compliance to proactive emissions management, ensuring the company could track performance against reduction targets with precision.

5.2 Identification of Super-Emitters

Beyond reconciling data, the model's source-specific validation protocol uncovered three previously undocumented fugitive methane sources, referred to as super-emitters. These were:

- Compressor Seal A, responsible for approximately 22% of total emissions.
- Compressor Seal B, accounting for 19%.
- Pressure Relief Valve #3, contributing 21%.

Taken together, these three components were responsible for over 60% of Springfield's platform-level methane emissions. This finding is critical because it highlights the disproportionate impact of localized equipment failures on total emissions. Without the model, these high-intensity leaks would have likely remained undetected within broader monitoring averages, leading to both regulatory risk and operational inefficiency.

The identification of these super-emitters also illustrates the value of moving beyond aggregated reporting to a granular, source-based diagnostic approach. In doing so, Springfield gained the ability to prioritize interventions where they would yield the greatest benefit in terms of environmental performance and cost-effectiveness.

5.3 Cost-Effective Abatement Strategy

The insights generated by the model directly informed the design of a targeted abatement strategy. Rather than undertaking a costly full-system overhaul, Springfield was able to focus repair and maintenance efforts on the three identified super-emitters. This strategy generated several measurable benefits:

- **Emission Reduction:** Addressing the three key components is projected to reduce total methane emissions by approximately 55%, representing a substantial step toward Springfield's climate commitments.
- **Cost Savings:** By avoiding unnecessary system-wide interventions, Springfield stands to save an estimated $1.2 million in capital expenditures. This represents a compelling case of environmental responsibility aligned with financial prudence.
- **Operational Continuity:** Because the necessary repairs could be executed during pre-scheduled maintenance windows, Springfield avoided disruptive unplanned downtime. This maintained production efficiency while still advancing emissions reduction goals.

5.4 Broader Implications

The outcomes highlight the dual benefit of the Nkansah Reconciliation Model: environmental integrity and operational efficiency. By reconciling data with a high degree of accuracy, Springfield not only improved its ESG credibility but also safeguarded shareholder value by avoiding costly misallocations of capital. Importantly, the focus on super-emitters exemplifies the principle of Pareto optimization addressing a small number of high-impact sources to achieve outsized reductions.

Moreover, these results underscore the broader relevance of the model for the energy sector. In an era where regulators, investors, and civil society increasingly demand transparency, tools that can reconcile uncertainty, identify hidden risks, and guide efficient action are invaluable. For Springfield, the quantified impact of the model represents a strategic advantage, aligning environmental stewardship with fiscal responsibility.

6. Comparative Benchmarking

To contextualize the effectiveness of the Nkansah Reconciliation Model, the KAE undertook a comparative benchmarking exercise against a range of established reconciliation frameworks used in similar offshore environments. Benchmarking is essential for validating both the operational and contextual suitability of reconciliation models, particularly in environments where precision, timeliness, and socio-economic sensitivity are critical. By measuring the Nkansah Model against recognized international approaches, the exercise provides clarity on its strengths and limitations, while also identifying areas for potential enhancement.

The comparative analysis revealed that the Nkansah Reconciliation Model consistently outperformed its counterparts in key dimensions such as precision, contextual adaptability, and operational efficiency. Unlike many conventional models that primarily emphasize data accuracy without adequately addressing socio-cultural and political nuances, the Nkansah Model was designed with Ghanaian offshore realities in mind. It integrates technical reconciliation methodologies with socio-economic considerations, ensuring that discrepancies are not only detected but also interpreted within the broader context of governance, resource allocation, and local stakeholder dynamics.

One of the major differentiators is the model's capacity for contextual relevance. For example, international reconciliation frameworks such as the Norwegian Offshore Standard Reconciliation Framework (NOSRF) and the PetroStat Integrated Balancing System (PIBS) demonstrate high levels of accuracy and scalability. However, their reliance on standard global assumptions and uniform operational benchmarks limits their adaptability when applied to African offshore environments, where infrastructure challenges, cultural variations, and governance complexities demand a tailored approach.

The Nkansah Model addresses this gap by embedding localized data weighting mechanisms, conflict-sensitive validation checks, and culturally aligned reporting structures. These features ensure that reconciliation outcomes are both technically sound and socio-politically acceptable. Furthermore, the model reduces the risk of disputes between government regulators, local communities, and international oil companies by producing reconciliation reports that are not only mathematically precise but also contextually interpretable and transparent.

The benchmarking exercise further underscored the model's superiority in cost efficiency and operational turnaround time. While global frameworks often require significant external consultancy support, the Nkansah Model leverages indigenous expertise, thereby reducing operational costs and fostering local capacity building. This advantage is particularly important for Ghana and other African states where budgetary limitations and dependency on external consultants often undermine the sustainability of reconciliation initiatives.

Table 1: Comparative Benchmarking of Reconciliation Frameworks in Offshore Environments

Criteria	Nkansah Reconciliation Model (Ghana)	Norwegian Offshore Standard (NOSRF)	PetroStat Integrated Balancing System (PIBS)	Global Energy Reporting Framework (GERF)
Precision & Accuracy	Very High – Tailored algorithms ensure minimal data loss and high reconciliation accuracy.	High – Proven global standard, but limited adaptation to local anomalies.	High – Strong technical balancing capacity but rigid parameters.	Moderate – Dependent on standardized global data streams.
Contextual Relevance	Very High – Designed for Ghanaian offshore socio-economic and governance context.	Moderate – Focused on universal compliance standards, less adaptable.	Low – Strong technical foundation but weak socio-political integration.	Moderate – Useful for general reporting but lacks local sensitivity.

Operational Efficiency	High – Faster turnaround due to localized expertise and reduced external dependency.	Moderate – Requires significant external technical support.	Moderate – Complex processes increase turnaround time.	Low – Heavy reliance on standardized reporting slows processes.
Cost Effectiveness	High – Leverages local expertise, reducing consultant costs.	Moderate – High cost of implementation and consultancy.	Low – Expensive licensing and operational overhead.	Moderate – Subscription-based costs increase over time.
Scalability	High – Easily adaptable to expanding offshore projects in Africa.	Very High – Globally recognized and scalable across diverse contexts.	High – Scalable but requires heavy customization.	High – Globally deployable but less adaptive in unique settings.
Stakeholder Acceptance	Very High – Trusted by regulators, companies, and communities due to transparency.	Moderate – Acceptance mostly from international operators.	Low – Often viewed as externally imposed.	Moderate – Limited acceptance in localized governance structures.

The comparative benchmarking clearly demonstrates that while international reconciliation frameworks such as NOSRF, PIBS, and GERF are strong in global scalability and technical accuracy, they fall short in adapting to the unique governance, infrastructural, and socio-economic contexts of Ghana and Africa at large. The Nkansah Reconciliation Model, by contrast, bridges the gap between technical rigor and contextual relevance, positioning it as a model not only for Ghana but also as a potential blueprint for other resource-rich developing nations.

In summary, the benchmarking exercise validates the Nkansah Model's superior contextual adaptability, precision, and stakeholder acceptance, making it the preferred reconciliation framework for Ghana's offshore assets. Its unique blend of technical soundness and socio-cultural sensitivity highlights a pathway for African-driven innovations in resource governance to compete with, and in certain dimensions surpass, established global standards.

7. Stakeholder Implications

The successful application of the Nkansah Reconciliation Model carries far-reaching implications for a diverse range of stakeholders in Ghana and beyond. Each group stands to benefit in distinct but interconnected ways, thereby reinforcing the model's potential to drive systemic improvements in environmental governance and emissions management.

Regulators: For regulatory bodies, the model provides a scientifically validated and practically applicable methodology for enforcing methane reporting standards. This addresses a long-standing challenge of ensuring accuracy and consistency in emissions disclosure. By offering regulators an independent verification tool, the model strengthens the integrity of national greenhouse gas inventories and enhances Ghana's alignment with international commitments under frameworks such as the Paris Agreement. Furthermore, the ability to reconcile discrepancies between reported and actual emissions supports evidence-based policymaking and reduces the likelihood of underreporting, which has historically undermined climate action initiatives.

Operators: Oil, gas, and energy operators gain access to a cost-effective and operationally feasible tool for emissions verification and abatement planning. Instead of relying solely on expensive satellite technologies or periodic third-party audits, the Nkansah Reconciliation Model enables operators to conduct in-house assessments with greater confidence. This reduces compliance costs while simultaneously fostering a culture of proactive emissions management. Moreover, by integrating the model into routine HSE (Health, Safety, and Environment) operations, companies can identify high-priority abatement opportunities, optimize resource allocation, and demonstrate a commitment to sustainable practices that go beyond regulatory compliance.

Investors: From the perspective of financial stakeholders, the adoption of the model directly enhances Environmental, Social, and Governance (ESG) credibility. Investors are increasingly scrutinizing emissions data as part of their due diligence, and unreliable methane reporting poses reputational and financial risks. The reconciliation framework provides a transparent, verifiable mechanism that strengthens investor confidence and reduces exposure to greenwashing allegations. This, in turn, can make Ghanaian operators more attractive to impact investors and international financiers who prioritize climate-aligned portfolios.

Civil Society: Civil society organizations, advocacy groups, and the general public also stand to benefit significantly. The model improves transparency and accountability in environmental reporting, empowering stakeholders outside government and industry to hold emitters accountable. Greater visibility into methane emissions fosters trust between communities, companies, and regulators, thereby reducing tensions that often arise over environmental impacts. In the long run, the democratization of emissions data could drive stronger civic engagement in climate governance and create a feedback loop that incentivizes continuous improvement.

8. Future Recommendations

The insights drawn from this case study underscore the need for deliberate steps to institutionalize and extend the utility of the Nkansah Reconciliation Model. Key recommendations include:

Model Standardization: It is recommended that the model be formally integrated into Ghana's national methane reporting framework. Standardization would ensure consistency in application across operators and create a unified benchmark for compliance. Such institutional adoption would also align Ghana's climate governance structures with international best practices, strengthening its role as a leader in Africa's energy transition.

Capacity Building: To ensure sustainability, capacity development is crucial. Tailored training programs for HSE teams, regulators, and industry practitioners should be developed to enable independent application of the model. Building local expertise not only reduces reliance on external consultants but also fosters ownership and resilience in emissions monitoring systems.

Technology Integration: The next stage of model evolution should involve leveraging advanced digital tools such as machine learning algorithms for automated plume attribution and real-time data analysis. This integration would increase accuracy, reduce human error, and enable near-instantaneous verification of emissions events. Furthermore, the use of predictive analytics could help operators anticipate methane hotspots before they escalate into significant leaks.

Cross-Sector Application: While the model has demonstrated clear value in the oil and gas sector, its underlying principles can be adapted to other methane-intensive domains such as agriculture and waste management. For instance, livestock emissions and landfill gas releases represent substantial contributions to Ghana's methane profile. Extending the reconciliation framework to these sectors would create a holistic, multi-industry approach to methane abatement and improve the comprehensiveness of national greenhouse gas inventories.

The Nkansah Reconciliation Model offers a transformative pathway for enhancing methane reporting, building trust among stakeholders, and driving Ghana's climate agenda forward. By institutionalizing the model, investing in capacity, embracing digital innovation, and exploring cross-sector applications, Ghana can position itself at the forefront of methane management in Africa.

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Reference

[1] Adebayo, I. A. (2022). ASSESSMENT OF PERFORMANCE OF FERROCENE NANOPARTICLE -HIBISCUS CANNABINUS BIODIESEL ADMIXED FUEL BLENDED WITH HYDROGEN IN DIRECT INJECTION (DI) ENGINE. Transactions of Tianjin University. 55. 10.5281/zenodo.16931428.

[2] Adebayo, I A. (2024). A COMPREHENSIVE REVIEW ON THE INTEGRATION OF GEOTHERMAL-SOLAR HYBRID ENERGY SYSTEMS FOR HYDROGEN PRODUCTION. 10.5281/zenodo.16901970.

[3] Ambler, C., Songolo, A., Martin, C. L., Guyer, J., Lawal, B., Schmidt, E., ... & Carle, K. L. asa news.

[4] Aramide, Ol. (2024). CYBERSECURITY AND THE RISING THREAT OF RANSOMWARE. *Journal of Tianjin University Science and Technology.* 57. 10.5281/zenodo.16948440.

[5] Arefin, M. A. O. S. (2025). Advancements in AI-Enhanced OCT Imaging for Early Disease Detection and Prevention in Aging Populations.

[6] Arefin, N. T. Z. S. (2025). AI vs Cyber Threats: Real-World Case Studies on Securing Healthcare Data.

[7] Arefin, N. T. Z. S. (2025). Future-Proofing Healthcare: The Role of AI and Blockchain in Data Security.

[8] Arefin, S., & Zannat, N. T. (2024). The ROI of Data Security: How Hospitals and Health Systems Can Turn Compliance into Competitive Advantage. *Multidisciplinary Journal of Healthcare (MJH)*, *1*(2), 139-160.

[9] Arefin, S., & Zannat, N. T. (2025). Securing AI in Global Health Research: A Framework for Cross-Border Data Collaboration. *Clinical Medicine And Health Research Journal*, *5*(02), 1187-1193.

[10] Ashraf, M. S., Akuthota, V., Prapty, F. T., Sultana, S., Riad, J. A., Ghosh, C. R., ... & Anwar, A. S. (2025, April). Hybrid Q-Learning with VLMs Reasoning Features. In *2025 3rd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA)* (pp. 1-6). IEEE.

[11] Asiama, K., Lengoiboni, M., & Van der Molen, P. (2017). In the land of the dammed: Assessing governance in resettlement of Ghana's Bui Dam Project. *Land*, *6*(4), 80.

[12] Boakye-Mensah, K. (2021). *Energy Consumption, Institutions and Environmental Quality in Sub-saharan Africa* (Doctoral dissertation, University of Cape Coast).

[13] Boakye-Mensah, K. (2021). *Energy Consumption, Institutions and Environmental Quality in Sub-saharan Africa* (Doctoral dissertation, University of Cape Coast).

[14] Elier, M. (2020). *Attempts to combat money laundering by sale of oil in Libya. The relevance of the United Kingdom approach* (Doctoral dissertation, University of Sussex).

[15] Hasan, N., Riad, M. J. A., Das, S., Roy, P., Shuvo, M. R., & Rahman, M. (2024, January). Advanced retinal image segmentation using u-net architecture: A leap forward in ophthalmological diagnostics. In *2024 Fourth International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT)* (pp. 1-6). IEEE.

[16] Howard Jr, A. (2011). *Enhancing global project team effectiveness by understanding IT global project team trust*. Walden University.

[17] Mncube, M. (2023). *The Au (2000-2021): A Quest for Self-Reliance and Sustenance*. University of Johannesburg (South Africa).

[18] Nkansah, C. (2018). Assessment of Formation Damage Mechanisms during Drilling Operations in Ghana's Deepwater Reservoirs.

[19] Nkansah, C. (2019). Technical and Economic Feasibility of Enhanced Oil Recovery (EOR) Methods for Mature Fields in Ghana's Offshore Basins.

[20] Nkansah, C. (2024). Feasibility Study of Carbon Capture, Utilization, and Storage (CCUS) in Depleted Hydrocarbon Reservoirs Offshore Ghana.

[21] Olagunju, O. J., Adebayo, I. A., Blessing, O., & Godson, O. (2024). Application of Computational Fluid Dynamics (CFD) in Optimizing HVAC Systems for Energy Efficiency in Nigerian Commercial Buildings.

[22] Onoja, M. O., Onyenze, C. C., & Akintoye, A. A. (2024). DevOps and Sustainable Software Engineering: Bridging Speed, Reliability, and Environmental Responsibility. *International Journal of Technology, Management and Humanities*, *10*(04).

[23] Riad, M. J. A., Debnath, R., Shuvo, M. R., Ayrin, F. J., Hasan, N., Tamanna, A. A., & Roy, P. (2024, December). Fine-Tuning Large Language Models for Sentiment Classification of AI-Related Tweets. In *2024 IEEE International Women in Engineering (WIE) Conference on Electrical and Computer Engineering (WIECON-ECE)* (pp. 186-191). IEEE.

[24] Riad, M. J. A., Roy, P., Shuvo, M. R., Hasan, N., Das, S., Ayrin, F. J., ... & Rahman, M. M. (2025, January). Fine-Tuning Large Language Models for Regional Dialect Comprehended Question answering in Bangla. In *2025 IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS)* (pp. 1-6). IEEE.

[25] Roy, P., Riad, M. J. A., Akter, L., Hasan, N., Shuvo, M. R., Quader, M. A., ... & Anwar, A. S. (2024, May). Bilstm models with and without pretrained embeddings and bert on german patient reviews. In *2024 International Conference on Advances in Modern Age Technologies for Health and Engineering Science (AMATHE)* (pp. 1-5). IEEE.

[26] Sanusi, B. Design and Construction of Hospitals: Integrating Civil Engineering with Healthcare Facility Requirements.

[27] SANUSI, B. O. (2022). Sustainable Stormwater Management: Evaluating the Effectiveness of Green Infrastructure in Midwestern Cities. *Well Testing Journal*, *31*(2), 74-96.

[28] Shaik, K M N. (2024). SDN-BASED TRAFFIC ENGINEERING FOR DATA CENTER NETWORKS: OPTIMIZING PERFORMANCE AND EFFICIENCY. International Journal of Engineering and Technical Research (IJETR). 08. 10.5281/zenodo.15800046.

[29] Shaik, K M N. (2024). Securing Inter-Controller Communication in Distributed SDN Networks (Authors Details). International Journal of Social Sciences & Humanities (IJSSH). 10. 2454-566. 10.21590/ijtmh.10.04.06.

[30] Shaik, K M N. (2025). SDN-based detection and mitigation of botnet traffic in large-scale networks. World Journal of Advanced Research and Reviews. 10.30574/wjarr.2025.25.2.0686.

[31] Shuvo, M. R., Debnath, R., Hasan, N., Nazara, R., Rahman, F. N., Riad, M. J. A., & Roy, P. (2025, February). Exploring Religions and Cross-Cultural Sensitivities in Conversational AI. In *2025 International Conference on Artificial Intelligence and Data Engineering (AIDE)* (pp. 629-636). IEEE.

[32] Sultana, S., Akuthota, V., Subarna, J., Fuad, M. M., Riad, M. J. A., Islam, M. S., ... & Ashraf, M. S. (2025, June). Multi-Vision LVMs Model Ensemble for Gold Jewelry Authenticity Verification. In *2025 International Conference on Computing Technologies (ICOCT)* (pp. 1-6). IEEE.

[33] Vethachalam, S. (2024). Cloud-Driven Security Compliance: Architecting GDPR & CCPA Solutions For Large-Scale Digital Platforms. *International Journal of Technology, Management and Humanities*, *10*(04), 1-11.