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Measuring gas flaring and emission costs through environmental management accounting and their impact on investment and disclosure decisions: An applied study of Al-Gharraf oil field, Iraq

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Abstract
In the oil sector, this study aims to implement an economic and environmental cost framework for environmental management accounting with the corresponding cost of associated gas flaring and its linked emissions, and to link that cost with investment decision-making, in addition to climate and sustainability disclosure. We consider the Al Gharraf oil field in Dhi Qar Governorate as an applied case in this study as an active producing field that has a publicly known development path. It is a reference point for published gas recovery and flare reduction projects. By combining documentary analysis of the references that cover environmental management accounting and disclosure with quantitative modeling, the study is based on a mixed approach to estimate flaring emissions and environmental cost at the field level. This is achieved through the use of a coherent methodology that uses World Bank data and sectoral analysis available to connect the published production for the field with Iraq's national flaring intensity. The findings illustrate the integration of wasted gas value costs with carbon costs and compliance costs, and disclosure costs into the integrated accounting framework, which is changing the way flare reduction projects are evaluated. It shifts them from being considered a limited environmental obligation to a sound investment decision with embedded economic and disclosure elements that can be aligned with the principles of IFRS S2, GRI 11, and GRI 305.

Keywords: Environmental Cost Accounting, Gas flaring, Al Gharraf field, Investment decision, Climate disclosure

1. Introduction

The oil sector's gas flaring is one of the most obvious examples of the poor nature of traditional accounting systems in addressing genuine environmental effects. Flaring and emissions continue to be treated by many oil companies as independent operations or compliance concerns rather than as a cost consideration that affects investments. Base-level environmental management accounting evidence is that a high proportion of environmental costs remain hidden within general accounts when they are not recast as physical and monetary flows that are quantifiable and actionable [1], [2]. Within the Iraqi context, Iraq is still ranked at the international level on the list of countries associated with high levels of gas flaring. According to the Global Gas Flaring

Tracker Report 2025, world flaring reached 148 billion cubic meters in 2023 and 151 billion cubic meters in 2024 [3], where Iraq was still ranked one of the countries contributing the most to this issue.

These figures are not just an environmental cost. They also demonstrate the depletion of an economic resource, whether for power generation or value addition in the oil and gas sector. Al Gharraf field is an appropriate applied case due to a report that reported an average production of 127 thousand barrels per day between April 2022 and March 2023, with a planned development to increase the production capacity to 230 thousand barrels per day. There are also published works on recovering gas from Al Gharraf and Nassiriya with a gas recovery capacity of 200 million standard cubic feet per day [4], [5]. Thus, studying flaring in this area is not only a theoretical guess but also based on theory. It draws on a realistic operating case that can be used to construct an applicable environmental accounting model. The significance of this study lies in the work in that it is not confined to flaring and emissions. It seeks to translate these into components of accounting cost affecting decision-making and then link those outputs to well-known disclosure requirements, notably IFRS S2 and guidance from the oil and gas industry, GRI 11 [6, 7] and GRI 305 [8], and the extractive transparency reports in Iraq [9].

2. Research problem

The problem of this study lies in the fact that information related to flaring and emissions in extractive industries, even when it is published in national or international reports, usually does not turn into internal environmental cost drivers that can play a real role in comparing investment alternatives. As a result, decisions about gas recovery projects or flare reduction often remain governed by a partial engineering or financial logic rather than a complete accounting logic that includes the value of wasted gas, avoided emissions compliance costs, disclosure costs, and climate-related transition risks [2], [1].

This issue is worse in Iraq due to the disconnect between external transparency and internal accounting. On the other hand, the field-level transparency analysis, including the taxes levied on the Al Gharraf field in certain years [10] and its appearance in EITI Iraq reports, has led to a certain degree of institutional and financial transparency regarding the extractive sector. On the contrary, there is no detailed public series that provides an actual number of flaring and emissions at the field level. So, it's not that flaring is not taken seriously as an environmental concern. The actual problem is that it is not very strong in being translated into an environmental cost accounting model which can be used for both investment decisions and systematic disclosure.

By identifying and quantifying the costs of gas flaring in the oil sector (e.g. lost gas revenue, maintenance costs, regulatory fines), and putting in place an internal carbon pricing system to factor these costs into a company's financial decision-making, gas flaring can be turned into an internal cost element. The cost of flaring and emissions can be broken down into a number of components, such as direct costs (e.g. fuel costs, maintenance), opportunity costs (e.g. lost revenue), environmental and regulatory costs (e.g. carbon taxes, compliance fees) and investment costs in flare reduction technologies. The value of wasted gas, in addition to carbon compliance and disclosure costs, increases the economic rationale for flare reduction projects through a more enlightened return on investment, and through reduction of the risk of regulatory changes. The outputs from the proposed model can aid in meeting transparency requirements when disclosing environmental impacts in accordance with IFRS S2, GRI 11, and GRI 305, as well as build materiality assessments and offer quantitative metrics to align with the financial impact of flaring, helping to increase accountability to stakeholders.

3. Research objectives

The goal is to create a model for the environmental cost accounting of flaring and emissions for an oil field in Iraq that can effectively estimate the cost of flaring and emissions and identify the cost drivers for the environmental cost, which can be measured in relation to flaring and emissions activities. This includes the estimation of flaring emissions and the development of a reference environmental cost for the Al Gharraf field from both the data and derived data. In addition, the model will consider different investment options that can be used to reduce flares and evaluate the impact of such investments on the resulting net economic and environmental benefits. Moreover, the outputs and elements of this model should be compatible with IFRS S2, GRI 11 and GRI 305 as issued by the IFRS Foundation in 2023 and GRI in 2021 and 2016.

4. Related literature

Environmental Management Accounting is a framework for making decisions. Physical information, such as uses of energy, materials, water, emissions and waste, is combined with monetary information, and environmental management accounting can assist management in planning, control, pricing and investment decisions, and support those decisions [1]. This reference also explains that one of the major drawbacks in traditional accounting systems is that a large proportion of the environmental costs are generally classed as operating costs, and this makes the true cost picture not apparent. The IFAC advice supports this perspective by associating environmental management accounting with stronger capital policies, better alternative analysis, more efficient use of resources, and a more uniform approach to dealing with environmental hazards and obligations in terms of financial management [2]. From this perspective, gas flaring should not be considered a separate environmental problem in and of itself. This is an easy-to-measure and easy-to-explain economic harm quantifiable by monetary value and a firm's accounting statements.

The debate over gas flaring is not one that is all about climate emissions, as reported by the World Bank. It also represents a waste of a resource which could be utilised in electricity generation, gas products or support of energy infrastructure. The 2025 report also indicated that global flaring in 2024 was 151 billion cubic meters (cbm), as many of the key oil-producing economies continue to fail to capture associated gas [3].

In Iraq, the published data show that flaring is still very high, and this makes it necessary to bring it into the logic of economic evaluation rather than reducing it to environmental compliance alone. Every cubic meter of gas that is flared means not only additional emissions but also lost value that could have been invested or redirected to another economic use [3].

IFRS S2 represents a major step forward in that it transforms climate disclosure from just a ‘narrative’ reporting on performance to offering substantive data that fits into the governance strategy, risk management metrics and targets [6]. Along these lines, the oil and gas industry guidance following IFRS S2 stresses measurements of environmental impacts from operational emissions and energy use as well as transition risks. GRI 11 completes this picture. It offers a sector-specific framework for oil and gas, concentrating on consistent high-quality disclosure of material impacts, as well as the transition to a lower-carbon economy. At the same time, GRI 305 directly deals with the disclosure of air emissions and greenhouse gases (GRI, 2021, 2016). And so any accounting model for flaring is strengthened by designing it from the beginning to give information that is useful both for management and for disclosure.

Al Gharraf is the case that allows linking such references with an applied field situation. Japan Petroleum Exploration Co., Ltd. provides detailed information on the field, including its location, partners, production and development plans, which is a tangible basis for a study [4]. Additionally, EITI Iraq reports place the field within the institutional and financial setting of the extractive sector, whereas Baker Hughes’ project on Nassiriya and Al Gharraf gas shows just how gas recovery is not merely an academic notion, but part of the real investment activity in the area [5], [10]. Therefore, the research gap is not in the absence of literature on environmental management accounting, flaring, or disclosure. The real gap is in the weak connection between these three areas inside an applied accounting model at the field level, especially in the Iraqi context.

5. Materials and methods

This study adopted an applied research design with a mixed nature that combines documentary analysis and quantitative modelling in order to build an accounting framework for measuring the environmental cost of flaring and emissions in Al Gharraf field and linking it with investment and disclosure decisions. This choice was based on the fact that the research problem cannot be handled through a purely descriptive method or a purely financial one because the phenomenon under study lies at the intersection of three connected dimensions, which are the environmental dimension, the accounting dimension, and the investment disclosure dimension [1], [2].

The case of the study was Al Gharraf oil field located in Al Rifai district north of Dhi Qar Governorate. It was selected as an Iraqi producing oil field for which published operational data are available regarding production, operating structure, and expansion plans, in addition to its connection with published projects related to gas recovery and flare reduction [4], [5]. This field was chosen because it brings together several features that make it suitable for applied analysis. These include the existence of published oil production that can be used as a quantitative basis for analysis; the existence of a declared development activity that supports the investment side of the study; its direct relation to associated gas investment and its suitability as an Iraqi case within a national sector characterized by high flaring rates [3].

The study relied on three levels of data. The first one comprised the average production in the field, the partner and operator, the targeted production capacity, and some indicators on gas recovery projects. Official and institutional published sources were used to collect these data, primarily from JAPEX, PETRONAS, and Baker Hughes [4, 5].

The second set of national and sectoral published data will be delivered by the end of the first semester of the 2020-21 school year.

This included the volume of flaring in Iraq, flaring emissions, extractive transparency reports, and international standards related to climate and sustainability disclosure. The study was conducted at this level based on World Bank reports, EITI, IFRS Foundation, and GRI.

Third, derived data comprised the estimation of reference flaring in the Al Gharraf field, the estimation of reference emissions, the estimation of the value of wasted gas, the estimation of carbon cost, and the estimation of some compliance and disclosure costs for modelling purposes. The data are made with published coefficients used to direct and national data, and they are reference data, not operational data measured in the field. Table 1 presents the direct, national and derived inputs that are used to develop the applied environmental cost accounting model for Al Gharraf field.

Table 1. Published and derived input data used in the study

Variable	Value	Unit	Type of Data	Source/Note
Average oil production in Al Gharraf field	127,000	barrels/day	Direct published data	Based on JAPEX published field data
Iraq's total flaring volume (2023)	18.02 billion	m^3/year	National published data	Used to derive national flaring intensity
Iraq's oil production	4.3 million	barrels/day	National published data	Used in calculating flaring intensity
National flaring intensity	11.48	m^3/barrel	Derived data	Calculated from Iraq's flaring and oil production data
Reference flaring in Al Gharraf	1.46 million	m^3/day	Derived data	Estimated using field production × national flaring intensity
Reference flaring in Al Gharraf	51.5	MMSCFD	Derived data	Converted from cubic meters per day
Emission factor	2.6	kg CO_2/m^3	Derived coefficient	Used for estimating reference emissions
Reference emissions	1.38 million	tons CO_2/year	Derived data	Based on reference flaring × emission factor

Variable	Value	Unit	Type of Data	Source/Note
Reference gas price	4.463	USD/MCF	Assumed reference input	Used to estimate annual wasted gas value
Shadow carbon price	50	USD/ton CO_2	Assumed reference input	Internal decision-support value
Compliance and monitoring cost	3.0 million	USD/year	Estimated model input	Conservative estimate
Disclosure and sustainability cost	1.5 million	USD/year	Estimated model input	Conservative estimate

A hybrid environmental cost accounting model specifically designed for measuring the cost of flaring and emissions and for associating this cost with investment and disclosure decisions was the main instrument of the study. The model has four analytical layers which are interconnected. The first one is the physical layer, which involves the amount of oil production, reference flaring volume, and the resulting emissions. The second is the monetary layer, comprising the cost of wasted gas, carbon cost, compliance costs, and disclosure costs. The third one is the investment layer, involving analysis of the possibilities of reducing flares in relative scenarios. The fourth is the disclosure layer: matching the outcomes with the IFRS S2, GRI 11, and GRI 305 requirements [2]. Based on data published by JAPEX [4], the study used the average production of Al Gharraf field in the period from April 2022 to March 2023, which was 127000 barrels per day. In Iraq, the data for 2023 was used for the total volume of flaring that reached approximately 18.02 billion cubic meters, with the production rate of oil around 4.3 million barrels per day. From that, the intensity of flaring was calculated in each country thus:

National flaring intensity = 18.02 billion m^3 / (4.3 million barrels per day × 365) = 11.48 m^3 per barrel

This intensity was not chosen as a representative characterization of the flaring behavior of the field, but rather as a proxy for flaring in Al Gharraf [3].

Reference flaring was estimated as the national flaring intensity times Al Gharraf production as below:

127000 × 11.48 = 1.46 million m^3 per day. After converting the units, the estimated reference flaring for Al Gharraf became: 1.46 million m^3 per day ≈ 51.5 million standard cubic feet per day

The study was based on a reference coefficient of 2.6 kg CO_2/m^3 of flared gas that is applied in the analysis of regional sectors. Based on this, the following reference emissions were computed:

1.46 million m^3 per day × 365 × 2.6 kg per m^3 ≈ 1.38 million tons CO_2 per year

In the study, a reference gas price of 4.463 $/m3 was used. From this, the annual economic loss value of the gas was estimated to be:

51.5 MMSCFD × 365 = 18.80 BCF per year 18.80 million thousand cubic feet × 4.463 = 83.9 million dollars per year

The study adopted an internal shadow carbon price of 50 dollars for each ton of CO_2 as an internal evaluation tool rather than a national regulatory price. Based on this, the reference carbon cost reached:

1.38 million tons × 50 = 69.0 million dollars per year

In light of the limited published data at the field level, environmental compliance and monitoring costs were estimated at 3.0 million dollars per year. Disclosure and sustainability costs were also estimated at 1.5 million dollars per year. This was done to complete the applied model with a clear statement that both values are conservative estimates within the framework of the case study.

The study adopted three levels of analytical processing. The first level was descriptive and interpretive analysis of environmental management accounting and disclosure references. The second level was quantitative-derived analysis for estimating flaring emissions and environmental cost. The third level was scenario analysis for three flare reduction levels, which were 30 percent, 60 percent, and 90 percent. The study adopted a group of criteria to evaluate the quality of the proposed model. These were realism, accounting validity, applicability, decision relevance, sensitivity, and disclosure consistency [2], [6].

6. Results and discussion

The study adopts a hybrid model for accounting for the cost of flaring and emissions and linking it with investment and disclosure. This model is built on four connected layers. The first is the physical layer. This layer measures oil production, flared gas, and the resulting emissions. The second is the monetary layer. This layer converts these phenomena into an internal financial cost. The third is the investment layer. This layer tests the feasibility of flare reduction projects. The fourth is the disclosure layer. This layer links the outputs with the requirements of IFRS S2, GRI 11, and GRI 305 [2], [6].

The main equation of the model is defined as follows: $TEC = WG + CE + EC + DC + OC$

Where:
TEC = total environmental cost of flaring and emissions
WG = wasted gas cost
CE = carbon cost
EC = environmental compliance and monitoring cost
DC = disclosure and sustainability cost
OC = opportunity cost

Table 2 presents the structure of the proposed model and clarifies the meaning of each cost component included in total environmental cost.

Table 2. Components of the proposed environmental cost accounting model

Symbol	Component	Definition	Unit	Nature
TEC	Total Environmental Cost	Total annual cost associated with flaring and its linked environmental and disclosure burdens	USD/year	Output
WG	Wasted Gas Cost	Economic value of associated gas lost through flaring	USD/year	Monetary
CE	Carbon Cost	Estimated cost of CO_2 emissions based on a shadow carbon price	USD/year	Monetary
EC	Environmental Compliance and Monitoring Cost	Cost of environmental monitoring, auditing, and compliance activities	USD/year	Monetary
DC	Disclosure and Sustainability Cost	Cost of preparing, managing, and verifying climate and sustainability disclosure	USD/year	Monetary
OC	Opportunity Cost	Foregone value from alternative economic uses of captured gas or avoided transition impacts	USD/year	Strategic/estimated

This model brings together the operational accounting, investment and disclosure dimensions. It is also measurable because it depends on variables that can be observed or derived. At the same time, it is decision-relevant because it is designed to support comparison between investment alternatives. It is also flexible because it can be applied to one field or extended to comparisons across multiple fields [2].

Based on JAPEX data, the Al Gharraf field produced 127000 barrels per day on average during the period from April 2022 to March 2023 [4]. At the national level, flaring in Iraq reached about 18.02 billion cubic meters in

2023, with oil production close to 4.3 million barrels per day according to published analysis. On that basis, national flaring intensity can be estimated as follows:

18.02 billion m3 ÷ (4.3 million barrels per day × 365 days) = 11.48 m3 per barrel

When this reference intensity is applied to Al Gharraf production, the result is:

127000 × 11.48 = 1.46 million cubic meters per day.

This volume is converted into standard cubic feet, where the reference flaring level becomes about 51.5 million standard cubic feet per day. If sectoral analysis employs the emission factor, which is about 2.6 kg CO2 for each cubic meter of flared gas, annual reference emissions for Al Gharraf would correspond to about 1.38 million tons of CO2 per year [3]. Table 3 shows stepwise derivation of the reference flaring volume and associated emissions for Al Gharraf field based on published production data and Iraq's national flaring intensity.

Table 3. Applied database for reference flaring and emissions estimation in Al Gharraf field

Item	Formula/Calculation	Result
Average oil production in Al Gharraf	Published field data	127,000 barrels/day
National flaring intensity	18.02 billion m^3 ÷ (4.3 million barrels/day × 365)	11.48 m^3/barrel
Reference flaring volume	127,000 × 11.48	1.46 million m^3/day
Reference flaring volume (converted)	Unit conversion	51.5 MMSCFD
Annual reference flaring volume	51.5 × 365	18.80 BCF/year
Reference annual emissions	1.46 million m^3/day × 365 × 2.6 kg/m^3	1.38 million tons CO_2/year

To calculate the cost of wasted gas, the study used a reference gas price of 4.463 dollars per thousand cubic feet. Based on that, the annual reference flaring volume in Al Gharraf is approximately:

51.5 MMSCFD × 365 = 18.80 BCF per year

Accordingly, the estimated economic value of wasted gas is:

18.80 million thousand cubic feet × 4.463 dollars = 83.9 million dollars per year

As for carbon cost, the study adopted an internal shadow price of 50 dollars per ton of CO2e, not as a binding Iraqi regulatory price but as a conservative internal decision value that is acceptable within environmental economic analysis and consistent with international trends in carbon pricing [3]. On that basis, the reference carbon cost in Al Gharraf is approximately:

1.38 million tons × 50 dollars = 69.0 million dollars per year

Environmental compliance and monitoring cost as well as disclosure cost were estimated conservatively within the case study framework at:

3.0 million dollars per year for monitoring, auditing and compliance costs

1.5 million dollars per year for disclosure data preparation and internal and external verification costs

Accordingly, the total reference environmental cost of flaring in Al Gharraf becomes:

Wasted gas = 83.9 million dollars
Carbon cost = 69.0 million dollars
Compliance and monitoring = 3.0 million dollars
Disclosure and sustainability = 1.5 million dollars
Total = 157.4 million dollars per year

Table 4 presents the estimated annual environmental cost of flaring in Al Gharraf field after monetizing wasted gas, carbon emissions, compliance requirements, and disclosure-related burdens.

Table 4. Estimated annual environmental cost of Flaring in Al Gharraf field

Cost Component	Estimated Value (USD/year)	Basis of Estimation
Wasted gas cost	83.9 million	18.80 BCF/year × 4.463 USD/MCF
Carbon cost	69.0 million	1.38 million tons CO_2 × 50 USD/ton
Compliance and monitoring cost	3.0 million	Conservative estimated annual cost
Disclosure and sustainability cost	1.5 million	Conservative estimated annual cost
Total environmental cost	157.4 million	Sum of monetized components

The study is founded on the fact that there is a declared gas recovery project for Nassiriya and Al Gharraf; the gas capacity is 200 MMSCFD, and this provides a realistic basis for the flare reduction scenario for Al Gharraf. The study applies three assumptions of reductions from the reference estimate of flaring in Al Gharraf (51.5 MMSCFD): 30 percent, 60 percent, and 90 percent. Table 5 compares the three scenarios of flare reduction for gas recovery, avoided emissions, economic returns, and investment feasibility.

Table 5. Investment scenarios for flare reduction in Al Gharraf field

Scenario	Flare Reduction	Recovered Gas	Annual Gas Value	Avoided Emissions	Avoided Carbon Value	CAPEX	OPEX	Net Annual Benefit	Payback Period
Scenario 1	30%	15.45 MMSCFD	25.2 million USD	0.414 million tons CO_2/year	20.7 million USD	45 million USD	5 million USD/year	40.9 million USD	1.1 years
Scenario 2	60%	30.9 MMSCFD	50.3 million USD	0.828 million tons CO_2/year	41.4 million USD	72 million USD	7 million USD/year	84.7 million USD	< 1 year
Scenario 3	90%	46.35 MMSCFD	75.5 million USD	1.242 million tons CO_2/year	62.1 million USD	98 million USD	9 million USD/year	128.6 million USD	< 1 year

The first scenario is a 30% reduction. In this scenario, the recovery would be approximately 15.45 MMSCFD or 4.92 BCF annually with a direct economic value of approximately 25.2 million dollars per year. It would also prevent approximately 0.414 million tons of CO2 per year, or approximately $20.7 million per year in shadow carbon price costs. The net annual benefit would be approximately 40.9 million dollars and the payback period would be approximately 1.1 years.

The second scenario is a 60% reduction. In this scenario, approximately 30.9 MMSCFD or 11.28 BCF/year would be recovered, valued at approximately 50.3 billion dollars/year (direct value). It would also save approximately 0.828 million tons of CO2 – that's the equivalent of 41.4 million dollars. Assuming a CAPEX of $72 million and an OPEX of $7 million per year, the study indicates that the net annual benefit is approximately $84.7 million, and the payback period is less than one year.

In the third scenario, the target is to reduce the target by 90%. This scenario would recover about 46.35 MMSCFD (or 16.92 BCF per year) at a direct value of about 75.5 million dollars per year. It also eliminates approximately 1.242 million tons of CO2, or the price of 62.1 million dollars. In summary, in the study, if CAPEX = 98 million dollars and OPEX = 9 million dollars per year, the net discounted benefit would be approximately 128.6 million dollars per year, and the payback period would also be less than one year. These findings suggest that incorporating the value of wasted gas and the value of carbon into the cost/benefit analysis of flare reductions constitutes a profound reorientation of the cost/benefit analysis equation.

It is very consistent with the philosophy of environmental management accounting, which is to make environmental costs elements of decision-making [2].

The results confirm that the traditional view of reducing flares as just an extra cost is not sufficient to provide a full economic view. By considering only wasted gas in terms of 'value', a significant loss is observed. Flaring is not only an extra environmental cost, but a financial one as well when combined with the carbon cost and the cost of compliance and disclosure. In this way, compliance projects for flares in a region like Al Gharraf may be transformed into value recovery projects with a real economic and strategic value, not to mention the fact that many projects have already been announced that concern the investment in gas in Al Gharraf and Nassiriya [5].

The results also suggest that the model suggested is not only for the purpose of creating internal figures. It also is more proclivity towards mature reporting. In IFRS S2, there is disclosure on the climate-related governance strategy, on climate-related risk management metrics and targets, and quantifiable material that can be traced back to the areas of climate-related governance and risk management metrics. Likewise, GRI 11 and GRI 305 require that the material impacts, emissions, and management are disclosed. It makes the model outputs useful at the same time both internally as well as for external disclosure [6]. The result indicates that gas flaring in Al Gharraf field is not only a huge environmental issue, but also an economic one as well, even if the assessment is conservative. The value of wasted gas, along with the cost of carbon, compliance, disclosure, and the annual burden of flaring, could only be computed when the cost of flaring and the costs of carbon and compliance were combined with the value of wasted gas in the same accounting framework. Thus, if the indicator is not included in the assessment of investment, the assessment may be quite misleading [2].

This result is supported by our previous hypothesis in which a positive association was considered between the reference flaring volume in the field and the estimated total environmental cost. The more flaring that occurs, the more flaring gas is wasted, as well as emissions and, consequently, carbon cost, disclosure burden, and transition risk. This is a clear example that flaring is not one environmental problem; rather, it is a problem of multiple aspects in a cost calculus. The results also support the second hypothesis. They also demonstrate that integration of the avoided emissions and value of recovered gas enhances the economic attractiveness of flare reduction projects compared to conventional financial analysis. A flare reduction project can be thought of in terms of an extra capital cost in the traditional approach. A value recovery project, however, is what it would be under the proposed model, and one that also provides financial, environmental, and disclosure benefits. This is in line with the fundamental concept of environmental management accounting to reveal unrecognized environmental costs and translate them into effective decision-making tools [1].

Otherwise, the results of the model are linked with the requirements of IFRS S2, GRI 11 and GRI 305, in order to support the third hypothesis. The model not only generates numbers internally. It also provides information which may be reconverted into climate and sustainability disclosure reports, such as governance, strategy, risk management metrics and targets, emissions and impact management approaches [6, 11]. The results of the three investment scenarios also supported the fourth hypothesis. The more the analysis considered the total environmental cost, rather than solely the direct capital cost, the more appealing the scenarios looked. This conclusion is further reinforced by the fact that the scenarios developed in this study were not based on completely speculative technical solutions. Instead, it was based on an actual operating environment in relation to the official gas recovery project in Al Gharraf and Nassiriya [5, 12].

Even so, the results should be understood within their methodological limits. Flaring and emissions in Al Gharraf were not measured directly from published field records [13, 14]. They were derived from Iraq's national flaring intensity. This means that the results represent a high-value reference estimate rather than a direct operational measurement. Still, this limitation does not weaken the scientific value of the study. On the contrary, it highlights the importance of developing more detailed field-level measurement systems in future research. Table 6 demonstrates how the outputs of the proposed model can be translated into climate- and sustainability-related disclosure in line with IFRS S2, GRI 11, and GRI 305.

Table 6. Alignment of model outputs with climate and sustainability disclosure requirements

Model Output	Decision Relevance	IFRS S2 Link	GRI 11 Link	GRI 305 Link
Reference flaring volume	Measures operational inefficiency and environmental burden	Metrics and targets	Sector-specific material impacts	Air emissions reporting
Reference CO_2 emissions	Quantifies climate-related exposure	Climate-related metrics	Sector climate impact disclosure	Direct GHG emissions
Wasted gas value	Shows economic loss from flaring	Strategy and resource allocation	Resource efficiency implications	Indirect support
Carbon cost	Reflects transition-related exposure and internal climate pricing	Risk management and metrics	Transition planning relevance	Emissions-related cost context
Compliance cost	Supports operational environmental governance	Governance and risk processes	Environmental management practices	Monitoring relevance
Disclosure cost	Reflects internal reporting readiness	Governance, reporting systems	Sector disclosure quality	Emission disclosure process
Scenario-based net benefit	Supports capital allocation and investment choice	Strategy and decision-useful metrics	Transition action perspective	Supports reporting of mitigation outcomes

The scientific contribution of this study lies in the fact that it does not deal with flaring as only an environmental issue and not as a purely engineering matter either. Instead, it places flaring within an integrated accounting framework that combines the environmental investment and disclosure dimensions. Its practical contribution lies in offering a tool that can be adapted for Iraqi oil fields where a similar gap exists between published or estimated flaring data and the actual use of those data inside the accounting system and decision-making process.

7. Limitations of the study

The limitations of this study come from the fact that the official published data on Al Gharraf field mainly focus on production operation expansion plans and associated gas investment projects and do not include direct detailed data on actual flaring volumes and emissions at the field level. The available sources indicate that the field produces about 127 thousand barrels per day on average, with a plan to raise capacity to 230 thousand barrels per day and that there is an official project to invest gas from Nassiriya and Al Gharraf at a capacity of 200 million standard cubic feet per day in addition to the launch of a first phase in Al Gharraf at 37 million cubic feet per day.

Even so, these sources do not provide direct and complete field measurements of flaring and emissions needed for detailed quantitative modelling. For this reason, the study relied on a clearly stated derived estimation approach while some compliance and disclosure items remained estimated for modelling purposes. This reflects methodological honesty more than it reflects weakness in the study [4], Ministry of Oil, 2021, 2025a, 2025c, Thi-Qar Oil Company, 2025a, Extractive Industries Transparency Initiative, 2023, [3].

8. Conclusions

The study has found that the traditional accounting perspective or environmental perspective to solve the problem of gas flaring in the oil industry is no longer sufficient in a context where the need for information has grown and the need for accountability for climate change. The Al Gharraf case demonstrated how redefining flaring in the accounting sense from an external impact to an internal decision cost is not just another compliance challenge, but a primary challenge. By means of the proposed model, it was clear that flaring is not only the loss of an economic resource that could be used, but also emissions that are subject to internal pricing, as well as compliance costs, disclosure costs, and transition risks associated with the broader transition pathway to global climate. It also demonstrates the profound impact of integrating these elements in an environmental cost accounting model on how the project of flare reduction is assessed.

This allows for this type of project to be viewed not only as environmental duties, but also as investments that have an economic, environmental, and disclosure return. This finding is most relevant within the Iraqi context, as at the national level, the levels of flaring are extremely high; thus, developing models similar to this one in oil fields would go a long way to enhance resource use efficiencies and improve disclosure quality and sectoral governance. In this regard, the primary contribution of this study is the applied framework that integrates the concept of environmental management accounting, gas flaring investment decisions, and climate disclosure into one model. This link is an important scientific and professional contribution, particularly in the Iraqi environment, which requires more mature accounting tools to take into account the environmental aspects in decision-making in the oil sector.

9. Recommendations

It is important to have a separate account for the environmental cost center in Iraqi oil fields to ensure environmental compliance and accountability, and to separate the costs of flaring emissions compliance and disclosure from other general operating costs. Also, in future studies, direct field-level measurement systems for flaring and emissions would be less dependent on derived estimation, as they will be developed as well at the field level on a monthly or quarterly basis. An internal shadow carbon price in capital feasibility studies will allow Iraqi oil companies to factor in the cost of emissions in investment studies.

Furthermore, the emphasis needs to be placed in the recovery models beyond CAPEX and OPEX, to include the value of wasted gas. The mapping of internal information systems with IFRS S2, GRI 11 and GRI 305 will help to enhance consistency between internal accounts and external disclosure. Comparative studies between Al Gharraf oil field and other oil fields in Iraq can be useful to measure variations in flaring intensities and costs, as well as the impact of flare reduction on investment. Lastly, further studies need to be conducted to consider other factors like opportunity costs associated with electricity, gas, and liquids financing effects, reputation, and transition risks. Also, artificial intelligence [15] and machine learning [16, 17], optimization techniques [18, 19], cloud computing technology [20], Internet of Things [21], and microwave devices [22, 23] can support the objective of this study as future trends.

Declaration of competing interests

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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Author contributions statement

Ahmed Mohammad Hamzah contributed to the conceptualization of the study, the design of the research framework, and the analysis of data. He was responsible for drafting the initial manuscript and integrating feedback from co-authors. Thaer Omran Mousa played a key role in data collection and field measurements related to gas flaring and emissions at the Al-Gharraf Oil Field. He also contributed to the interpretation of results and provided critical revisions to the manuscript. Sarmad Salman Doaim was involved in the literature review and provided expertise in environmental management accounting. He assisted in refining the methodology and contributed to the discussion of findings, ensuring alignment with current academic standards. All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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