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Key Performance Indicators for Sustainable Production Evaluation in Oil and Gas Sector

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Abstract

The oil and gas sector has a significant impact on sustainable development, making it important for the sector to implement serious changes in the way it does business. Oil and gas operations involve both upstream activities, and downstream activities. Due to the nature of these activities which cause high risks, companies work continuously to reduce the significance of their adverse impacts on the environment and people. Thus, evaluating the sustainable production in this sector is become a necessity. This paper proposes a set of Key Performance Indicators (KPIs) for evaluating the sustainable production believed to be appropriate to the oil and gas sector based on the triple bottom line of sustainability. The Analytical Hierarchy Process (AHP) method is applied to prioritize the performance indicators by summarizing the opinions of experts. It is hoped that the proposed KPIs enables and assists this sector to achieve the higher performance in sustainable production and so as to ensures business sustainability.

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Keywords: analytic hierarchy process; oil and gas sector; key performance indicators; sustainable production

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1. Introduction

The oil and gas sector has grown significantly over last decade, making it important for the sector to implement serious changes in the way it does business. This sector is among the largest in the world, with increasing revenues and costs necessary to provide customers with the energy that they require in maintaining their style of living. Oil and gas operations involve both upstream activities, including all processes before the raw material is refined; exploration, drilling, extraction, storage, shipping, etc., and downstream activities, which involves the refining, selling and distribution of the product. Due to the nature of these activities which engender high risks, companies work continuously to reduce the significance of their adverse impacts on the environment and people [1]. The industry has had a checkered past, evidenced by high profile issues like the Santa Barbara oil spill in 1969 in California and Deep water Horizon disaster in the Gulf of Mexico in 2010. Further, companies in the sector were behind major environmental and human rights controversies in many regions in the world. In the early of 1990s, the operations of Shell Company in the Niger Delta in Nigeria resulted in the pollution of the river and tensions with local citizens of the Ogoni region. In 2003, Indigenous residents in Ecuador filed a lawsuit against Chevron for the pollution of Amazon rainforest, and the impact of that on their health. In the last few years, the sector has made steps in advancing toward sustainability [2].

Companies in the sector have been reporting their sustainability efforts - also referred to as "corporate citizenship or environmental, social and governance (ESG) reporting". This inventiveness has become an integral part of the way individual companies choose to engage stakeholders and help foster informed dialogue and understanding [3].

Operations oil and gas companies have potential impacts on the environment as well as health, safety, social and/or economic implications. Companies in the industry generally have systematic processes in place to manage and reduce environmental impacts. From a social perspective, companies should describe their overarching social contribution strategy. This may include descriptions of corporate objectives, engagement strategy on social investments, decision-making criteria, and spending to support community development. Companies can include details on whether initiatives are community-owned and driven, third-party or company facilitated [4].

2. Methodology

The most commonly used indicators for sustainable production evaluation in the oil industry is referred to the World Business Council for Sustainable Development (WBCSD). In this study, the KPIs of the 'Triple Bottom Line' (TBL) identified for this study, based on Global Reporting Initiatives GRI G3 guidelines (Launched in 2006) and best-practice oil companies.

The methodology has three main stages. First, the initial KPIs for sustainable production evaluation were identified and derived from the literature. Second, the initial KPIs were then validated to industry practices. Finally, a sustainable production performance evaluation based on the KPIs was developed using Analytic Hierarchy Process (AHP) methodology. The details are presented in the following sections.

2.1. Identification of KPIs

This study starts with the development of KPIs for sustainable production evaluation in oil industry through literature review. The initial KPIs have been constructed by adopting the triple bottom line of sustainability consisting of economic, environmental, and social performance factors. As a result, the initial KPIs consist of three factors divided into nineteen indicators were identified as shown in Table 1.

Table 1. Initial KPIs of sustainable production evaluation

Factors	Indicators
1. Economic	1. Net profits
	2. Revenue growth
	3. Return on assets
	4. Profit to revenue ratio
	5. Cost reduction
	6. Adherence to production plan %
	7. Improving delivery performance
2. Environmental	8. Greenhouse gas (GHG)
	9. Flaring gas
	10. Fresh water used
	11. Oil spills
	12. Waste reduction
3. Social	13. Injury frequency rate
	14. Social investment
	15. Local procurement and supplier development
	16. Preventing corruption
	17. Workforce diversity and inclusion
	18. Workforce engagement
	19. Workforce training and development

2.2. Conducting industry survey

The initial KPIs were then validated by an industry survey conducted to large oil company was chosen due to its current level of environmental commitments, its 40% market share in the Libyan oil industry, and its eight areas of operation with total employees more than 6000, engaged in crude oil and natural gas exploration, production and refining (fully integrated).

A total of 25 managers and senior engineers from different company departments were asked to rate the importance level of each KPIs of sustainable production evaluation in the oil industry. A five-point likert scale ranging from 1 (not important at all) to 5 (very important) was used to rate the perspective of participants to the importance level of the KPIs. The mean importance values ranged from 3.012 to 4.950 as presented in Table 2.

Table 2. Mean importance values of the initial KPIs.

Indicators	**Mean**
Revenue growth	4.950
Profit to revenue ratio	4.851
Net profits	4.812
Return on Assets	4.662
Preventing corruption	4.512
Injury frequency rate	4.451
Greenhouse gas (GHG)	4.422
Flaring gas	4.422
Oil spills	4.422
Adherence to production plan %	3.991
Workforce training and development	3.905
Improving delivery performance	3.795
Waste reduction	3.742
Fresh water used	3.696
Local procurement and supplier development	3.286
Cost reduction	3.256
Workforce engagement	3.165
Workforce diversity and inclusion	3.054
Social investment	3.012

The results indicated that Revenue growth is regarded as the most important KPI with a mean importance value of 4.950 representing a 95% importance. This is followed by profit to revenue ratio, net profits, return on **a**ssets**,** preventing corruption, injury frequency rate with values of (4.851, 4.812, 4.662, 4.512, 4.451) respectively. This

followed by GHG, flaring gas, oil spills with a same mean importance value of 4.422. On the other hand, local procurement and supplier development, cost reduction, workforce engagement, workforce diversity and inclusion, and social investment were regarded as the least important indicators.

Based on the results, the initial KPIs of sustainable production evaluation in oil industry have been modified. Due to the less importance, five indicators were removed from the initial KPIs. Finally, three factors with a total of fourteen indicators have been proposed as the KPIs for sustainable production evaluation in oil industry.

2.3. Developing AHP-based evaluation model

An evaluation model for sustainable production performance in oil industry was developed based on the identified KPIs. Analytic Hierarchy Process (AHP) methodology was applied in the developing of the model consisting of constructing the hierarchy, weighting the KPIs, rating the KPIs, and computing the scores of companies, and ranking the companies. Details are given in the following section.

3. Sustainable production evaluation model for the oil industry

The Analytic Hierarchy Process (AHP) has become one of the most widely used methods for multiple criteria decision making (MCDM) problems. It is a decision approach designed to aid in making the solution of complex multiple criteria problems to a number of application domains [5]. AHP methodology has several benefits [6]. First, it helps to decompose an unstructured problem into a rational decision hierarchy. Second, it can elicit more information from the experts or decision makers by employing the pair-wise comparison of individual groups of elements. Third, it sets the computations to assign weights to the elements. Fourth, it uses the consistency measure to validate the consistency of the rating from the experts and decision makers. The following steps show the development of an AHP-based model for sustainable production performance evaluation in oil industry.

3.1. Construct the hierarchy

The identified KPIs of sustainable production evaluation in the oil industry are used in constructing a hierarchy. The three groups were defined and constructed in the hierarchy including goal, factors, and indicators. In the hierarchy, evaluating sustainable production performance of oil industry is set to be the goal. The next level consists of TBL factors of environmental, economic, and social. The third level consists of the indicators that described each of factor with a total of fourteen. The hierarchy is showed in Fig. 1

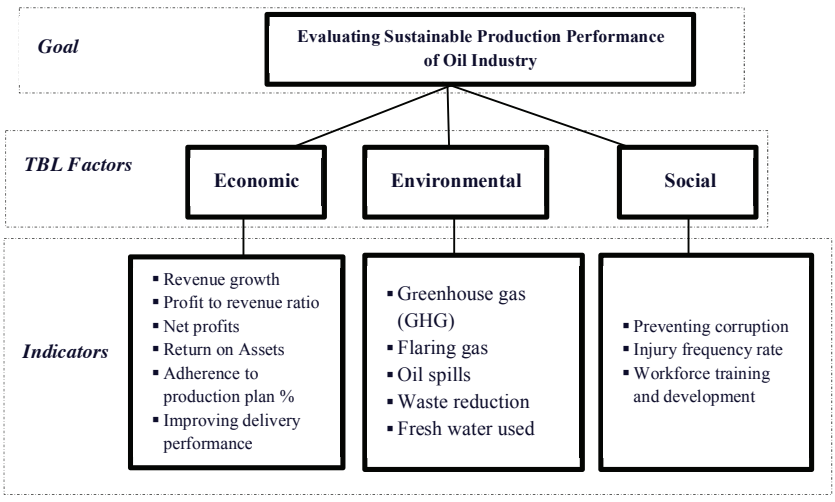

Fig. 1. The hierarchy structure of KPIs.

3.2. Weighting the KPIs

Once the hierarchy has been constructed, the importance weight of the KPIs should be calculated. A pairwise comparison questionnaire was then designed. A total of five senior managers from the oil company were consulted to give their preferences on the KPIs. Those managers were carefully selected based on their experience in oil industry. The pairwise comparisons were determined between factors, and indicators within each factor of the KPIs.

A scale of 1 to 9 (1= equally, 3= moderate, 5= strong, 7= very strong, 9= extreme) was used to reflect these preferences. The Consistency Ratio (CR) was used to check the consistency of the pairwise comparisons for each expert. The CR values are less than 0.1 which means it matches the consistency test. If it is not yet consistent, the comparison has to be repeated again.

Answers to each question were geometrically averaged before calculating the importance weights. Then a pairwise comparison matrix was constructed. The consistency test was performed to all the combined pairwise comparison matrixes.

The results show that the Consistency Ratio (CR) values ranged from 0.0105 to 0.0198, which means that all the pairwise comparisons are consistent since the values are within the acceptable level recommended [5]. It indicates that the experts have assigned their preferences consistently in determining the importance weights of the KPIs of sustainable production evaluation in oil industry

Table 3 presents a summary of the result of the importance weights of the KPIs of sustainable production evaluation in oil industry. The importance weights show the importance value of one indicator over another indicator. In term of factors, economic is the highest importance weight with a value of 0.4569. Net profits (0.0982) is regarded to the highest important indicator to economic factor. With regard to environmental factor, flaring gas is the most important indicator with a value of 0.0.0878 over another. Preventing corruption (0.0874) is considered much more important indicator than another in term of social factor.

Table 3.The importance weights of KPIs

Factors	***Weight***	***Indicators***	***Weight***
1. Economic	0.4569	1. Revenue growth	0.0869
		2. Profit to revenue ratio	0.0758
		3. Net profits	0.0982
		4. Return on Assets	0.0605
		5. Adherence to production plan %	0.0692
		6. Improving delivery performance	0.0663
2. Environmental	0.2894	7. Greenhouse gas (GHG)	0.0667
		8. Flaring gas	0.0878
		9. Oil spills	0.0794
		10. Waste reduction	0.0201
		11. Fresh water used	0.0354
3. Social	0.2537	12. Preventing corruption	0.0874
		13. Injury frequency rate	0.0865
		14. Workforce training and development	0.0798

3.3. Rating the KPIs

A scale range from 1 to 7 is used in this study to assess performance of each of the KPIs, where: 1= highly poor; 2= lowly poor; 3= lowly fair; 4= highly fair; 5= lowly good; 6= highly good; 7= excellent

3.4. Computing the company scores

The values generated from the performance rating are combined with the corresponding importance weights of the KPIs to obtain the company scores. The company score is calculated for the overall score and as well as for individual score of each factor. The overall score and individual score of each factor of companies are then classified into four performance levels based on the following rules:

If 1 ≤scores ≤3 then performance level is poor
If 3 <scores ≤5 then performance level is fair
If 5 <scores ≤ 7 then performance level is good
If scores > 7 then performance level is excellent

The overall score and the individual score of factor of the companies evaluated are then ranked in descending order. The company with the highest score can be considered as attaining best practice.

4. Case study results

The evaluation model has been applied to a case of exploration, production and refining Oil Company in Libya. The production managers were asked to evaluate their three oil fields using the 1 to 7 scale on the KPIs of sustainable production evaluation. The rating values are used to calculate the company score consisting of the overall score and the individual scores of each factor. The overall score and individual score of each factor of the companies compared are presented in a final result. The overall score of three oil fields compared is presented in Fig. 2

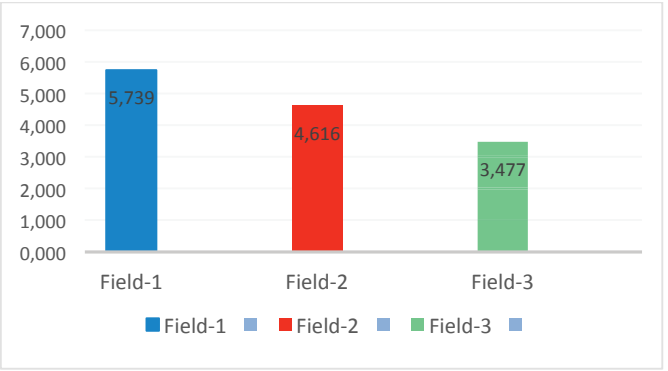

Fig. 2. The overall score of fields compared.

It can be seen that field-1 has attained the highest overall score with a performance level of good. On the other hand, filed-3 has the lowest overall score with a performance level of poor. In order to provide a detail of the overall score, the individual scores are also computed for each factor of KPIs as shown in Table 4.

Table 4. The individual scores of fields compared.

Fields compared	**performance level (Individual score)**			
	Economic	Environmental	Social	Overall score
Field-1	6.872 (Good)	4.321 (Fair)	6.025 (Good)	5.739 (Good)
Field-2	5.765 (Good)	5.995 (Good)	2.087 (Poor)	4.616 (Fair)
Field-3	4.405 (Fair)	2.161 (Poor)	3.865 (Fair)	3.477 (Fair)

The ranking and performance level of fields obtained are quite varied. Field-1 is to be the top rank for all factors with score (5.739). The Field-2 has the individual score of environmental factor higher than the Field-1. It can be concluded that the Field with the lowest overall score might be not the worst in all the factors. In order to make a quality decision making, these things need to be viewed in detail to prioritize the company's performance indicators when evaluating sustainable production.

5. Conclusions

Oil and gas operations involve multiple activities. Due to the nature of these activities which cause high risks, companies work continuously to reduce the significance of their adverse impacts on the environment and people. Thus, it is essential to evaluate the sustainable production in this industry.

Based on the results, three factors with a total of fourteen indicators are proposed as the KPIs of sustainable production evaluation in oil and gas sector. An evaluation model then developed using Analytic Hierarchy Process (AHP) methodology. The hierarchy structure is established based on the proposed KPIs of sustainable production evaluation in oil and gas sector. Then, the importance weights of the KPIs assigned by pairwise comparisons and calculated using AHP methodology. To assess the performance, the KPI is rated using a scale of 1 (highly poor) to 7 (excellent). Then, the company's scores and rank are computed to assess sustainable production performance against the KPIs.

A case study was conducted to a Libyan oil industry company. The results show the existing performance level on company's strengths and weaknesses. It provides suggestions and directions for companies to take appropriate actions in improving their sustainable production performance particularly in environmental and social factors. The model aids companies in achieving the higher performance in their sustainability efforts and so as increasing competitiveness. Future work will further incorporate the evaluation model to the development of sustainable production evaluation tool for the oil and gas sector.

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